From Historical Mapping To Historical Geographical Information System

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Introduction

Historical GIS

Historical Geographical Information Systems(or Historical GIS) have gained a lot of interest in the recent years. Very broadly, this term encompasses all softwares and numerical data which aim to represent, analyze or display past geographies, such as political boundaries. Thus, Historical GIS are various kinds of systems or data ranging from collections of existing georeferenced historical maps, such as the David Rumsey Collection[1] to large, diversified spatio-temporal database built from the combination of multiple sources, such as the Great-Britain Historical GIS, through specialized software dedicated to exploring and analyzing historical data.

One common practice in Historical GIS is to store georeferenced vector data. Vector data are geometries defined in terms of points, lines and polygons. They can be georeferenced so that their coordinates refer to actual geographical coordinates[2]. They are used to represent territory boundaries, physical features like rivers, roads or buildings and more generally, any geographically defined data. They offer enormous advantages for the exploitation of data. In particular, they are especially well-suited for making customized visualizations and for spatial and/or statistical analyses (see examples in Gregory, 2003)

Many countries have already built or started to develop their own national Historical GIS. The Great Britain Historical GIS (Gregory & Southall, 2003) has started its development in 1994 and has now become an extremely rich database. The China Historical Geographic Information System (Berman, 2003; Bol, 2007) has appeared in 2001 and aims to "establish a database of populated places and historical administrative units for the period of Chinese history between 221 BCE and 1911 CE". The United States followed in 2007, as well as other countries such as Belgium, Germany or Netherlands. On the other hand, there are very few projects of world-wide historical GIS, with a notable exception which is the Electronic Cultural Atlas Initiative[3].

Like for all computer software dealing with human data, a central point in Historical GIS is the data model, that is how historical data are represented in a structured form(see for example Berman, 2003). Such a model has to be developed both by history specialists and computer scientists since it is the link between real-world, fuzzy data and their numerical, formalized counter-parts. It must be able to describe historical data without loosing too much details while still being explicit enough to be usable by non-specialists.

Periodical Atlas Concept

The concept of a periodical atlas was first introduced by Christian Kruse (see Kruse, 1841). Well aware that historical accounts are often biased for geographical, philosophical or political reasons, Kruse created a set of sequential maps on the same base map of Europe and Middle East in order to give a global vision of the successive political situations and to allow easier comparison between regions and time frames.

A central aspect of this idea is the periodicity that is to draw maps at fixed time-intervals. This prevents from having to choose arbitrary events as a time basis. This contrasts with most historical atlases which either are based on some arbitrary events to define the time and area of the maps, or show specific events spanning multiple years, thus making the maps difficult to understand or even inconsistent. While both

[1] http://www.davidrumsey.com/

[2] They are actually dependent on which projection and/or datum(earth model) are used but this is a vast and complex domain which goes beyond our scope.

[3] http://www.ecai.org/

practices may be useful and justified in certain situations, they may be detrimental when trying to have a global and objective view of history. A periodical atlas avoids these problems as it shows maps representing specific moments of a same geographical area at regular time-intervals.

Periodical Historical Atlas of Europe

Euratlas has adopted this same periodical atlas concept and presents the countries under the form of mere entities, arising, changing size, moving or vanishing over time. Euratlas originally developed a historical atlas consisting in 21 maps representing the political landscape of Europe and the Mediterranean basin(see Figure 1) at the very beginning of each century starting from year 1 AD to year 2000 AD. These maps were drawn directly on a computer using the vector drawing software CorelDraw by combining information from more than 300 references and historical sources .

As outlined above, the peculiarity of this historical atlas is that it shows the exact political situation on each centennial year, thus allowing to have a sequential view of history of the same area with constant time-interval between each frame.

The Periodical Historical Atlas of Europe has a high-level of political details as it incorporates up to two levels of sub-state administrative divisions for most of the countries as well as a big number of cities with various sizes. It also uses colors gradients to indicate political dependencies between countries and fuzzy borders to show inaccuracies in data. The geographical precision is reasonable considering the depicted area with a precision between 5km and 10km in most places and up to 50km in desertic regions. Finally, the atlas shows several physical features which are a very dense network of rivers classified in two sizes and contour lines for five elevation levels (from 200m. to 3500m.).

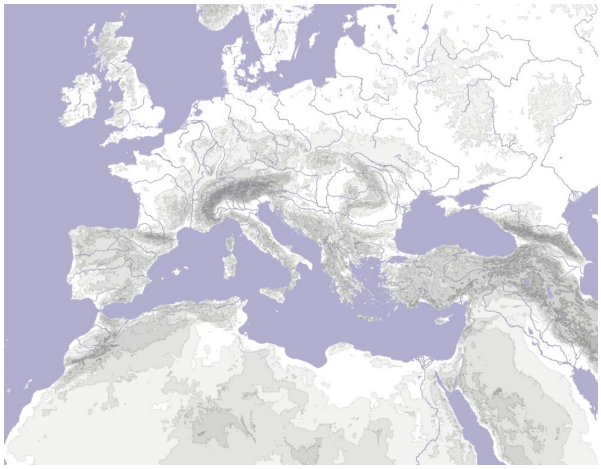

Figure 1: Area encompassed by the Periodical Historical Atlas of Europe

Georeferenced Historical Vector Data

Considering the great added value of a structured database compared to simple map drawings, the Periodical Historical Atlas of Europe has been entirely transformed into a historic-geographical database. This process included the definition and georeferencement of precise geometries of all territories from the vector drawings as well as the integration of all the available data such as political ownerships, names or dependency relationships into a formal model. This resulted in the Euratlas Georeferenced Historical Vector Data which consists in the 21 maps of the Periodical Atlas structured in a geographical database.

An important result of this process is the datamodel (see Nüssli, 2010 for a complete description) used to represent this data. This model aims to represent political entities and relationships in a very general way, independently of any country-specificity. It has been designed in order to keep a fair level of simplicity while still being able to capture the essence of political relationships. This model represents fixed political boundaries, so that it contains the political state of the depicted area at specific moments. This contrasts with a model which would represent political events at any time. In this respect, our model is not really time-enabled. It is rather a collection of political landscapes at different points in time with some relationships between these landscapes (see below).

Datamodel

This model is defined in a hierarchical way with different level of political territories such that the higher-level territories are built by combining several territories of lower levels. Thus, every political territory can be defined from the lowest level which is the provinces level, also called 2nd-level administrative divisions. Higher-level political territories are defined as combinations of provinces. In total, there are 4 levels of political entities which are, from lowest to highest: 2nd-level administrative divisions, 1st-level administrative divisions, states and supranational entities (see Figure 2).

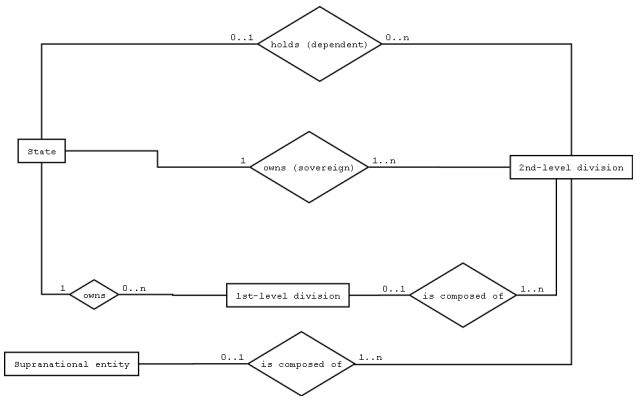

Figure 2: Entity-relationship diagram of the main parts of the Euratlas datamodel.

The territory of a state is thus defined as the union of all provinces owned by this state. However, each province may also sometimes be "held" by another country. This term is used to denote a political dependency relationship. Thus a province may have an *owner*, which is the sovereign state having en effective control of the territory, and possibly a *holder*, which is a dependent state claiming, retaining or exercising the control over the province. Thus, some states are sometimes only *holder* of some provinces and not *owner* of any province. They consequently are non-sovereign, dependent or vassal states.

The 1st-level administrative divisions is an intermediary optional level between provinces and states. Each province territory may possibly belong to a 1st-level administrative divisions either of its *owner*, or of its *holder*. It is then possible to have only some of the provinces of a given country belonging to 1st-level administrative divisions.

An additional separate political level is the autonomous people which is aimed to represent pre-nation populations without any known organized structure. In fact, they appear mainly in the first centuries but they also could be very useful if the data has to be extended to prehistory.

Thus, the political landscape of each century is represented through these different political levels. The link between the centuries is done at the state level. Indeed, each state has a specific unique numerical identifier which remains the same across the years. More precisely, it remains the same as long as there are no major changes in the government under consideration. It is then possible to follow a certain state through the years, for instance the Roman Empire until the year 1400.

The cities are represented independently from the territories and are defined in a year-independent way, which means that the city identifier and position remain the same across the years. Each city also has an associated year-dependent importance value, which represent the political influence of the city at a given century.

Finally, the data contains also a special layer called fuzzy borders which aims to represent inaccuracies in some political boundaries. They are simply defined as polygons overlapping boundary regions. The extent of these polygons towards the interior of the overlapped territories indicates the level of inaccuracies.

Nomenclature

Euratlas data is also composed of a wide gazetteer containing several names for all depicted territories, states, peoples or cities. The choice was made to give each entity its official name commonly used by the contemporary local people. When the official name was unknown, a variant form was used instead. As a result, some major states have unusual names. Among others, we have to mention:

- *Carolingian Empire* whose official name was *Kingdom of the Franks*,
- *Byzantine Empire* whose official name was *Roman Empire* or *Empire of Rhomania,*

- *Holy Roman Empire* whose official name was also *Roman Empire* until 1254,

However, usual or modern names are also provided as variants for many cases. These more usual names are of a great importance as they are often the only way for history non-specialists to relate with what they already know.

An important issue in naming is the character set or language used. In order to be able to deal with multiple languages, names are encoded in Unicode (UTF8), which allows to represent any character of any language in the world.

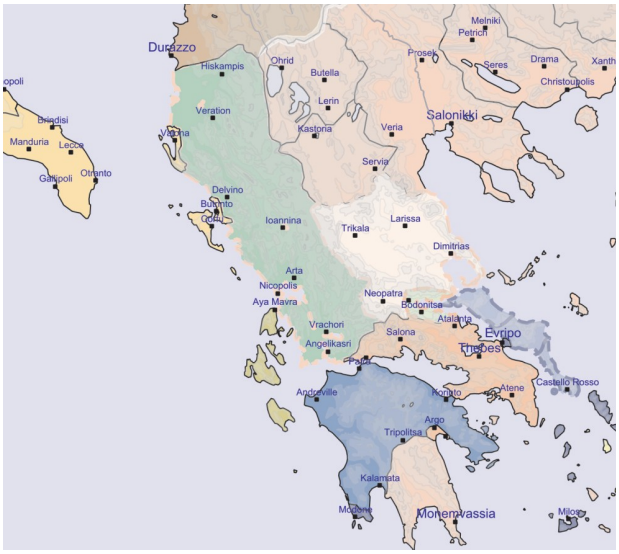

Figure 3: Example of map generated with the Euratlas Georeferenced Historical Vector Data. It represents Southern Balkan in year 1300. Dependent provinces are colored according to their holder state and surrounded by a dashed border colored according to their owner state.

Applications

Euratlas Georeferenced Vector Data offers a great potential for various kinds of applications from interactive historical atlas to spatial and historical analyses, possibly by combining with other data sources. Indeed, although forcing a formal model to store historical events data may be sometimes detrimental for an accurate representation of reality, it brings the great advantage of allowing complex automatic analyses that wouldn't be possible otherwise.

Periodis Expert[4]

Periodis expert (see Figure 4) is an interactive historical atlas built from the Georeferenced Historical Vector Data which replaces the Periodical Historical Atlas of Europe. More precisely, it is a front-end software that allows end-users to navigate through this data in an intuitive way. It offers most options one can expect from a map software based on vector data: unlimited zoom variations, independent layers, dynamic labeling or contextual information. Moreover, it also provides powerful search tools as well as some functionalities to create customized maps. This software shows the great potential of the Euratlas Georeferenced Historical Vector Data for creating history exploration softwares. More details, screenshots as well as a working demo version of Periodis Expert can be found on the Euratlas website.

[4] http://www.euratlas.net/history/periodis_expert/index.html

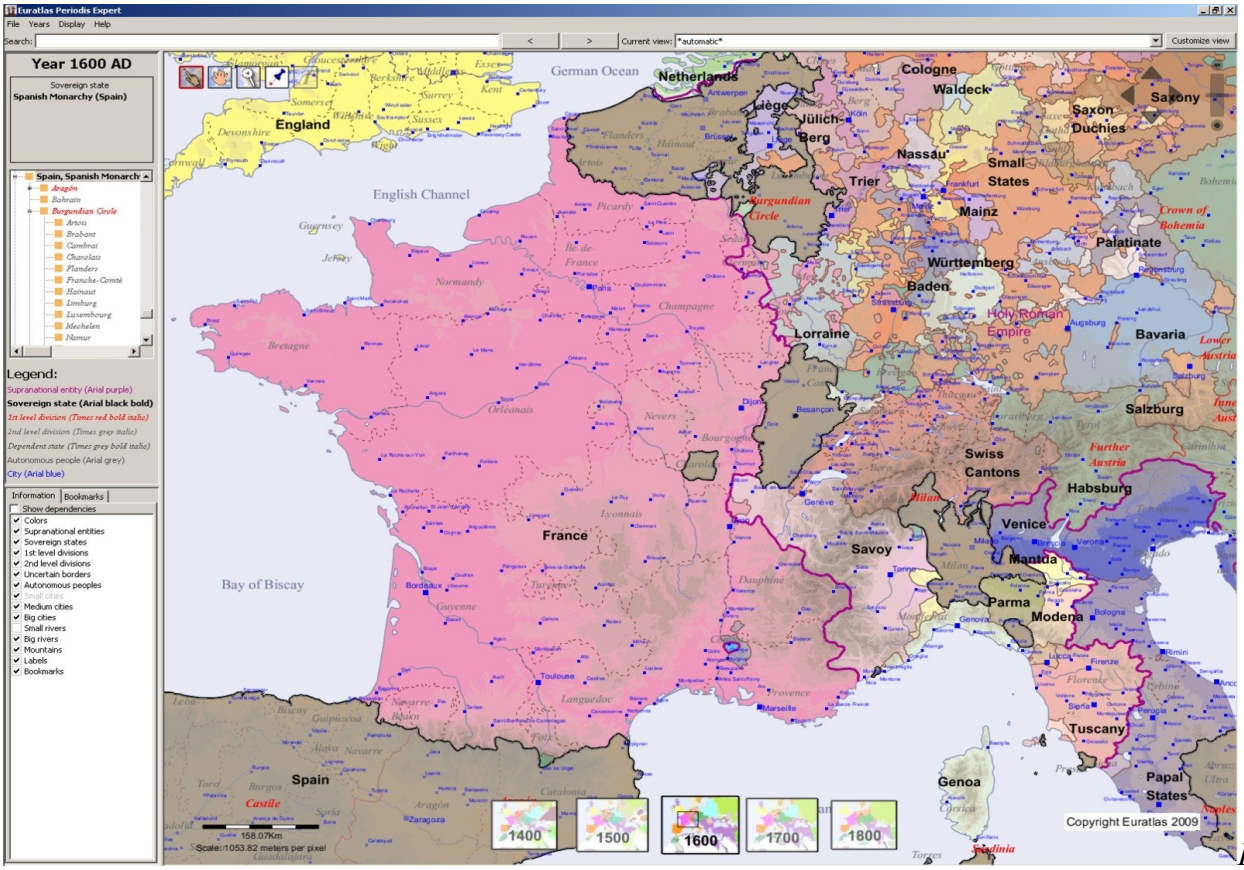

Figure 4: Screenshot of Periodis Expert showing central Europe in year 1600 with Spain territories selected. The political hierarchy of Spain is partially visible on the upper part of the left panel.

Scientific use

Euratlas Historical Georeferenced Vector Data also has a great potential to conduct various historical and/or geographical analyses. Indeed, the fact that the political territories are structured in a database allows to make complex automatic analyses combining geographical, political and/or physical information. For instance, we can analyze the evolution of the number and surfaces of the provinces of a given state, or the political evolution of a given region. The possibilities are numerous and interested readers can refer to (Gregory, 2003) for extensive examples.

Figure 5 shows an example of such an analysis. This map represents the political stability of the different regions with a color going from blue(stable) to red(unstable). It has been computed by counting the number of different *owners* that each region had through the 21 centuries contained in the data. The intensity of the color shows the quantity of data available which is simply the number of centuries for which the region has political territory defined[5]

Of course, this is just a very simple example and more developed analyses should be performed, especially by combining with other sources of data.

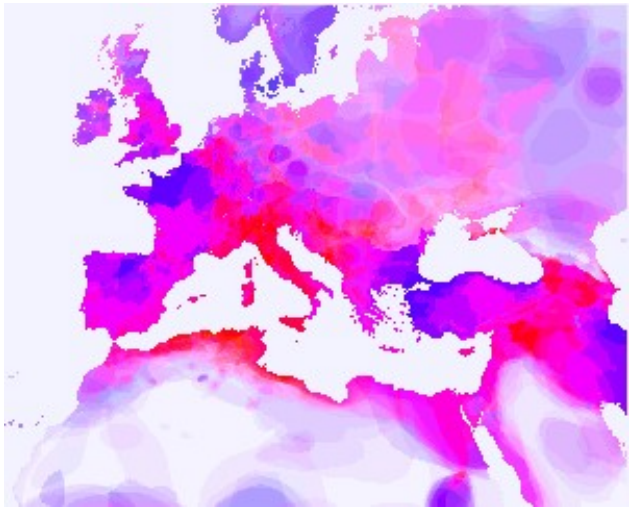

Figure 5: Simple spatial analysis done on the Euratlas data. The colors represent the political stability from blue(stable) to red(unstable).

[5] Indeed, some regions like Russia or North Africa have no territories defined in the first centuries, generally because of a lack of information.

Discussion

We have presented the Euratlas Georeferenced Historical Vector Data, a novel dataset which results from the integration of the Periodical Historical Atlas of Europe in a spatio-temporal georeferenced database. Thus, it shows the difficulty and advantages of transforming simple map drawings, for which the main purpose is display into structured historical GIS-enabled data which offers a wide variety of usages.

An important result of this process is the development of a datamodel which can represent accurately and simply historical data in a formal way. The model presented above fulfills these requirements. Indeed, this model can represent states along with up to two levels of sub-state administrative divisions. Moreover, it can represent simple dependencies between two state. Finally, it offers also a simple solution to indicate inaccuracies in data by providing a special fuzzy border layer. For these reasons, it forms a complete consistent model to represent political data and still keeps a relative simplicity.

Of course, several improvements are still possible. One of the main limitation concerns the dependency model which is too simple to represent faithfully all situations. Indeed, only a single type of dependency, namely asymmetric *owner-holder* relationship between two states. Thus, It is not possible to have symmetric situations where both states have the same influence, nor is it allowed to have more than two states exercising control on a territory. While the current model can handle the vast majority of encountered situations, some cases would require a more complex schema. For instance, the English domains in France in the XIII century for which the status is difficult to establish, or the status of Egypt under the partial control of United Kingdom and Ottomans in 1900.

Another weakness of this model is that there is no direct relationships at the territory level between the years. More precisely, the only link between the years is made through the states and cities identifiers. It is thus possible to relate the territories of a given state through the years but it is not possible to relate for example the territories of a specific province through the centuries. Actually, this may be achieved by performing some well-chosen spatial queries that would compare provinces shapes between the years but this is not as effective as having the relation encoded directly the data.

Nevertheless, the resulting dataset is unique and innovative and offers a global picture of the political evolution of Europe. Thanks to its periodical nature, it doesn't rely on any preconception about what and/or where are the important events which shaped history. On the opposite, it gives an objective overview of political boundaries changes across time. The main limitation of this data is the time resolution which is relatively low with only one map per 100 years.

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