A Chorem–based Method for Visualizing Evolutionary Scenarios

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In this paper we describe the research carried out within an international project, launched among several research institutions. The project is meant to define cartographic solutions able to better represent geographic information extracted from (spatial) database contents, which refer both to static objects and evolutionary phenomena.

When dealing with scenarios referring to complex issues, such as political, economic and demographic problems, the usage of visual metaphors represents a more effective solution in supporting users to locate facts and new patterns. An actual support for human activity to model and analyze the reality of interest may indeed benefits from an immediate synthesis of data of interest, which disregards details. Such a synthesis may then represent the starting point for further processing tasks aimed to derive spatial analysis data, as well as to support expert users in decision making, thus bridging the gap between the expected applications and domain expert users.

The solution we propose to achieve this aim is based on the *chorem* concept and on its capability to summarize both static objects and dynamic phenomena, by associating them with schematic visual notations.

In agreement with the definition of the French geographer Pr. Roger Brunet [1], *chorems* are a schematic territory representation, which eliminates any not necessary detail to the map comprehension. The *chorem* term derives from the χωρα Greek word, which means space or territory.

Brunet proposed 28 elementary chorems, each of them representing an elementary spatial configuration. By integrating them in a choromatic map, various spatial phenomena may be represented at different scales.

Figure 1(b) shows an example of chorematic map derived from a traditional map of the Mexico country (see Fig. 1(a)), where the following aspects are highlighted:

- the geometric shape,
- the most important cities,
- the different climatic areas,
- the flows representing the direction of people migration.

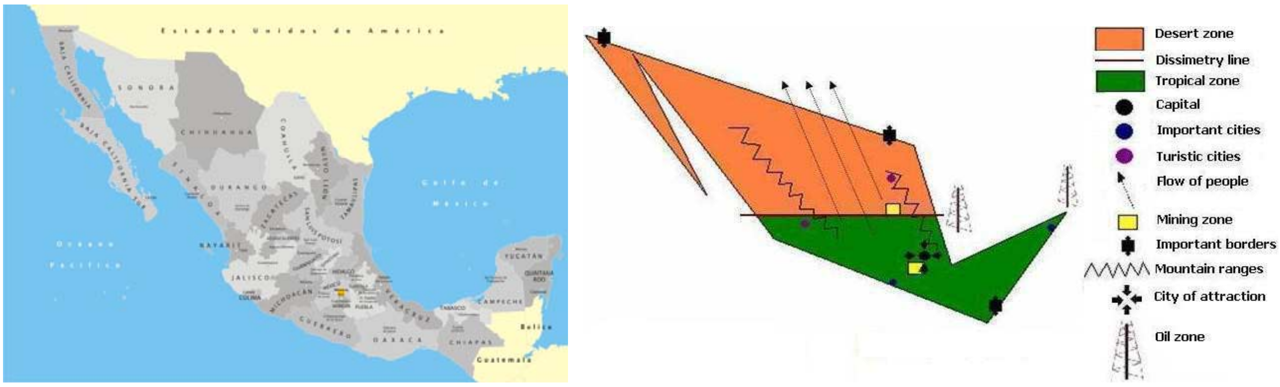

Figure 1. A traditional map (a) and a chorematic map (b) showing some thematic aspects.

Since their appearance, *chorems* had a large diffusion in the geographer community where they were widely developed and used for specific purposes [2, 3]. In fact, different classifications were provided, starting from Brunet's proposal, as well as a large amount of manually produced chorematic maps were exploited, either to give a global view of objects of interest or to get an insight into a specific issue.

However, the lack of a rigorous approach for chorem creating and assembling has determined the proliferation of *ad hoc* solutions, which in many cases may fail in sharing information they are meant to represent.

In this paper we describe some guidelines as well as the system we are implementing to automate chorems creation, starting from datasets of interest. In particular, we provide a formal definition for the chorem structure on which also a proper classification is based. Moreover, the architecture of the system is detailed in terms of modules, subsystems and languages. Initial results can be found in [4]

Chorem Definition

Pattern: An interesting regularity discovered in a geographic database by using data mining functions. Patterns can be used as a starting point to identify spatio-temporal phenomena and relations between them.

Example: in Mexico, where the agave is cultivated, there is the tequila production.

Proto-chorems: Data items necessary and sufficient to execute SQL queries, data mining and spatial data mining functions. They represent cleaned data necessary to run analyses for finding patterns, from which several chorems can be obtained.

Example: tables with data referring to population displacements and spatial data related to areas, from which a chorem of macro-areas and a chorem of flow can be derived.

Chorem element: Each basic graphic element that represents a single geographic data.

Examples: a point representing a city, an arrow representing a flow, as shown in Fig. 1.

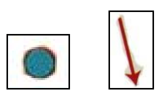

Figure 1. Point and arrow.

Chorem: Set of chorem elements of the same typology.

Examples: the most important cities of a country, the main flows between the cities, as shown in Fig. 2.

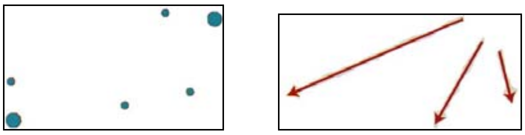

Figure 2. Cities and flows.

Chorematic Map: Set of chorems which represents an overall schematization of a place, where important characteristics for the user occur. A legend is associated with chorems, which explains their meaning, as shown in Fig. 3

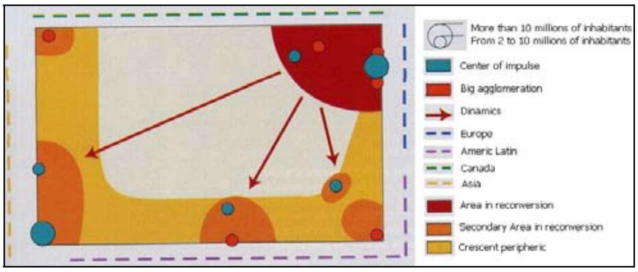

Figure 3. A Chorematic map of USA showing dynamics among main places

Chorem Classification

Chorems can be classified into two main categories, Geographic Chorems and Phenomenal Chorems. Geographic Chorems represent objects with simple geographic features, such as Points, Lines, Polygons, and objects made up of their combinations, such as Networks. The sets of polygons with peculiar characteristics depicted in Fig. 3 represent instances of Geographic Chorems.

Phenomenal Chorems describe spatio-temporal phenomena among Geographic Chorems. The initial set of Phenomenal Chorems we have identified consists of three types, namely Flow, Tropism, and Diffusion. The Flow represents people or object displacement among points or polygons. Dynamics shown in Fig. 3 represents an example of Phenomenal Chorems. The Tropism represents an attractive or repulsive space. For instance, it can be used for describing a city which attracts the population. Finally, the Diffusion represents a spatial extension or regression. For instance, it can be used for describing the development trend of a city in a particular region.

The architecture overview

The architecture of the proposed system is given in Fig. 4. It consists of two major subsystems, namely the extraction and the visualization subsystems. The former is meant to derive and manipulate the information from available datasets, the latter handles such information by assigning it a visual representation in terms of chorems and chorematic maps. The communication among the system components is based on a multi-level language, named *ChorML*. Based on the involved components, a proper *ChorML* level is used in order to map different specifications and derive formats useful to the running process.

Starting from a database, the *Chorem Extraction Subsystem* embeds both traditional and spatial data mining techniques, each of them devoted to accomplish a specific task. In particular, the spatial pattern discovery task is meant to extract spatial knowledge by applying clustering and aggregation procedures together with *SELECT*s queries to the database. Such a knowledge may be then translated into a set of chorems, which are expressed by an GML-like representation, named *ChorML0*. Sometimes, a reduction process may be necessary in order to find out the proper number of chorems to represent on a map, when a large amount of patterns are extracted. A set of Spatial Oracle functionality is adopted and extended to this aim.

Once both inter-chorem and topological relationships are computed, a *ChroML1* version is obtained where proper tags are added in order to handle information about how chorems are spatially bound.

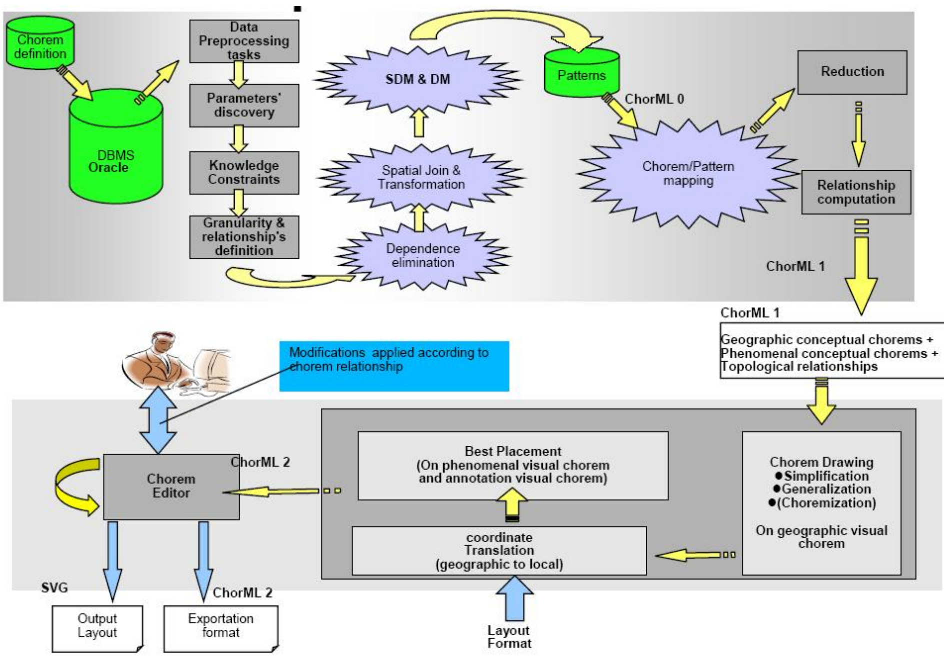

Figure 4. The architecture of the proposed system

Once the list of chorems and the set of constraints among them are obtained from the *Chorem Extraction* Subsystem, they are sent to the *Chorem Visualization* Subsystem in order to derive a visual representation of chorems and chorematic maps, both in terms of layout and semantic content. Four different tasks are performed by this subsystem, namely chorem drawing, coordinate translation, best-placement of chosen chorems and chorem editing. As for the chorem drawing, it is performed through three, not necessary interconnected, steps, named *simplification*, *choremization* and *generalization*, where some procedures and spatial operators are invoked in order to derive geographic visual chorems, namely a sketched representation of the involved elements.

The goal of next step consists of integrating phenomenal chorems and annotation onto the output map. This is accomplished by a multi-agent system whose aim is to spatially arrange chorems onto the chosen visualization format and determine their best placement, preserving structural and topological constraints among them. In order to guarantee the best placement requirement, independent sets of interrelated chorems may be aggregated onto different maps, thus providing users with more intuitive and readable chorem maps.

Some difficulties can occur regarding chorem placement and layout, as well as further refinements affecting semantic and graphic properties may be required by users. To this aim, users are provided with a tool for chorem editing, which allows them to refine the expected output map. In particular, users can take part in composing the resulting chorematic map by editing, moving or deleting some elements within the chorematic map. In particular, the Chorem Editor may perform the following tasks:

1. import positioned chorems in *ChorML* language format,
2. chorem display starting from the information derived from the previous steps,
3. generation of chorem graphical representations based on SVG,
4. modification of both graphical representation and semantic structure of chorems,
5. export both a graphical representation (SVG) and a *ChorML* representation of chorems.

References

1. Brunet R.1986. La carte-modèle et les chorèmes. Mappemonde (Apr. 1986), 4-6.
2. Klippel A., Richter K.-F., Hansen S. 2005. Wayfinding Choreme Maps. In Proceedings of 8th International Conference, VISUAL 2005 (June, 2005) Edited by S. Bres.
3. Lardon S. 2003. Usage des chorèmes, graphes et jeux dans le diagnostic de territoire. Engref Pop'Ter. Clermont-Ferrand.
4. V. Del Fatto, R. Laurini, K. Lopez, R. Loreto, F. Milleret-Raffort, M. Sebillo, D. Sol-Martinez and G. Vitiello "Potentialities of Chorems as Visual Summaries of Geographic Databases Contents" *8th International Conference on Visual Information and Information Systems VISUAL2007*, Shanghai (CINA), 28 – 29 May 2007. G. Qiu et al. (Eds.): VISUAL 2007, LNCS 4781, pp. 537–548, 2007. Springer-Verlag Berlin Heidelberg.