

## ABSTRACT

Recent estimates suggest that 80% of all digital data generated today include geospatial referencing (e.g., geographic coordinates, addresses, postal codes, etc.). Indeed, most researchers agree that the geographic component represents an ubiquitous factor which both is an integral part of a territory and contributes to acquire knowledge about its phenomena. This awareness has a direct implication on studies conducted within the general domain of Earth and Environmental Science, where a parameter involved in the analytical methods is now focused on place and space. As a matter of fact, researchers from those disciplines have recognized that in order to turn large heterogeneous data volumes into information, the challenge is to develop methods capable to understand patterns and relationships in geographic space along with their change over time or processes that are responsible for them. To achieve this goal, human vision and domain expertise can be exploited together with computational tools. In particular, a visual representation and computing may contribute to better motivate pattern recognition and hypothesis generation, thus allowing better understanding of structures and processes, and supporting knowledge construction.

The aforementioned activities fall in the area of GeoVisual Analytics (or geospatial visual analytics). Geovisual Analytics belongs to the GeoVisualization research field and deals with problems involving geographical space and various objects, events, phenomena, and processes populating it. It benefits from the integration of different disciplines. In fact, the adoption of visual interactive methods from GeoVisualization, and their integration with new possibilities offered by computational techniques, set the basis for effective support to data exploration and decision-making processes, due to the capability of combining geospatial information with “human vision and domain expertise”.

The increasing volumes of geospatial data presents a difficult challenge in the exploration of patterns and relationships. With such large volumes of data, common geospatial analysis techniques are often limited in revealing patterns and relationships, a process necessary for understanding underlying structure and related real world processes. New interactive visualization tools are being envisaged to deal with large datasets in order to synthesize information and perform complex analytical tasks. Along this line, our research efforts have been focusing on new cartographic approaches which could support daily analysts' work by producing synthesis and presentation of discovered patterns in a concise and understandable way. In order to decide the class to which the pattern belongs, common classification or pattern recognition methods are used to compare the unknown pattern with all known reference patterns, on the basis of some criteria for the similarity degree. These techniques are difficult to apply in the case of unknown data, as it is not obvious what mechanisms or rules are behind data of interest. New approaches in exploratory geospatial data analysis and visualization are needed to effectively extract patterns and relationships, and represent such data in a visual form that can better stimulate exploration, pattern recognition and hypothesis generation, as well as allow better understanding of structures and processes and support knowledge construction.

The objective of our research is to give support to decision makers when facing problems which require rapid solutions in spite of the complexity of scenarios under investigation. In order to achieve this goal our studies have been focused on GeoVisualization and GeoVisual Analytics research field, which play a relevant role in this scope, because they exploit results from several disciplines, such as exploratory data analysis and GIScience, to provide expert users with highly interactive tools by which they can both visually synthesize information from large datasets and perform complex analytical tasks.

The research we are carrying out along this line is meant to develop software applications capable both to build an immediate overview of a scenario and to explore elements featuring it. To this aim, we are defining methodologies and techniques which embed key aspects from different disciplines, such as augmented reality and location-based services. Their integration is targeted to realize advanced tools where the geographic component role is primary and is meant to contribute to a human-information discourse.

To address the abovementioned research issues, a methodology is proposed. It includes a paradigm for visual representation and navigation along with Geovisualization techniques aiming at experimenting it in different domains. Moreover, a theoretical basis has been defined for enhancing the role of visual metaphors by associating them with a composite structure capable to store different levels of summarized data. This enhancement is intended to offer alternative and different views of the data and stimulate the visual thinking process characteristic of visual exploration. Moreover, it aims to support advanced analytical tasks through the use of appropriately specified operators. The results of this research are new and they are relevant to perform analytical tasks and discovery knowledge from geographical databases. It advances the technological solutions for the wider scope of Geographic Information and provides sample cases, which document knowledge discovery from spatial databases by using GeoVisualization methods in that context. As a matter of fact, by applying such methods this research supports the process of planning and makes it a tool for human information discourse. This could be considered a preliminary work for building models and provides a relevant contribution to the development of advanced spatial analysis applications that can be exploited also through mobile devices. In particular, given the mobile device pervasiveness they could help decision makers handle emergency situations and crisis evolution by on site tools.