Geovisualization for End User Decision Support: Easy and Effective Exploration of Urban Areas

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In the current information age, the spatial information need of an end user is much more than querying a geospatial search system. In several scenarios of decision making, end users need to inform themselves about the multivariate geo-located facilities and infrastructure of urban areas, but the current means of geospatial search services does not provide the adequate assistance for such tasks. To gain more insights users need to find the relevant sources of information, explore these sources individually, and then intellectually merge the results into a personal decision. We believe that visualization methods could enhance the capabilities of geospatial search and databases tor decision support, but these visualizations could be extremely complex and affect the end users analysis with the information overload. In this paper we present our primary design of utilizing simple and knowledge-based visual interfaces for the easy and effective exploration of urban areas. Furthermore we discuss the associated challenges to support spatial decision making for diversity of users.

Spatial decision support is required to assist people for the development, evaluation and selection of proper policies, plans, scenarios, projects where the problems have a geographic component [2]. Most of the current systems are designed to assist the planning and decision making of a targeted group of experts, analysts or decision makers. However, citizens also need to explore the multivariate geo-located facilities and infrastructure of urban areas in several scenarios of decision making. The geospatial Web and community data sources contain huge and significant information about the geo-located facilities, but the end-user access of such data sources are limited due to static interfaces of current location-based services. Visualizations methods could be appropriate solution to tackle such limitations since one of the prime objectives of visual analytic research is to facilitate decision making process on top of highly complex and multi-dimensional data [3]. Andrienko et. al. [2] have discussed geo-spatial decision making as one of the main challenges and application of visual analytics in the spatial domain. There has been many visual analytical models and tools been developed to support critical business decision making process [4], but to assist general public in their decision making is still a major research challenge and focus in the domain of visual analytics, i.e., to increase end user empowerment. The clarification is required on how to use the visual analytical methods and tools on the geo referenced data of urban areas and help end-users for spatial decision making. In this work we are concerned with new simple and exploratory visualization models, which allow easy understanding of spatial semantics of the data set, and further spatial knowledge derivation from the user interaction. Our design decisions are inspired from the preliminary user study with ten users, which was a semi structured interview to gather end user requirements in realizing a decision support system for exploration of urban areas. The geospatial dataset was collected for various German cities via focused Web crawler [1], which was further enriched by OpenStreetMap. In the following sections we discuss our current geovisualization approaches, and further challenges to support end user spatial decision making.

Reducing information overload via simple and categorical visualizations: Spatial maps are the general basis of geovisualization interfaces. Most of the current geovisualization approaches embed too much of information on the maps to represent variety of geospatial attributes, e.g. the spatial distribution and spreading, sparseness and density, reachability and connectivity etc. The diversity and variety of such information on the map interface increases the information overload, and affects the understanding and decision making capabilities of end users. So there is a need of more simple visual representation to drive the user decision making process sequentially though interaction and exploration methods. Furthermore, one of the high points of our user study was the need for simplification in information representation. Most of the users wished for easy and simple visualizations while being asked about their need in realizing an ideal geospatial decision support system.

We have developed some simple visual representation of geospatial information on maps, e.g., a grid based division of a city map with the colored heatmaps (see Figure 1), which is an easy yet efficient visualization to provide the categorical information of geo-entities. One of the main observations of our user study was that users tend to visualize the geo attribute at low granularity. When being asked to list the important geo attributes for exploration, users mentioned the geo-relevance parameters with a categorical overview, e.g. shopping, sports, education, etc. The available geospatial data is at the high granularity with real physical addresses of local entities. So the need is to represent the geovisualization of spatial database with low level category based details to simplify the initial visualization for end users. In the grid based exploration, each cell represents a category via associated colors, which is estimated with respect to geo-entities inside the cell boundaries. We found that such user controlled categorical divisions are very significant for the end user analysis on the spatial distribution of an urban region/city, or for the comparison of different regions/cities.

(1) Grid based exploration

(2) knowledge-based support for decision making

Knowledge-based support via relevance and ranking of ge0-regions: There are several scenarios of decision making when the manual exploration or comparison of urban areas and regions becomes extremely complex due the diversity and quantity of user criteria of interest. In such circumstances end users might need assistance in specifying their spatial interest or for the analysis of geo-regions by knowledge-based computations. To cater such requirements we aim to support visual interface through querying and ranking assessments of geo-regions. Figure 2 shows our primary realization of such an interface, here users could define their current region of interest via drawing a query on the map of a city (a polygon query on the left side of interface), the system provides similar regions of interest on the user selected points of another city (circular regions on the right side of interface). The similarity is computed based on the categorical distribution of the geo entities in the regions. Further interaction models should give the opportunity to user to explore the categorical distribution and influence the ranking and retrieval process. There could be various situations when citizen could be benefited significantly with such knowledge-based support, for example if a person needs to move to a new city and prefers to find a similar neighborhood as of his/her current living region.

Designing for diversity via novel and context-based interaction: One of our main objectives is to design visual interfaces which can serve the diversity of users, since the requirements for individual users could be different, their criteria of interests could diverge and especially how they weight these criteria. Our aim is to develop appropriate interaction methods that could provide end users the control to adapt the visualization attributes with their individual needs. The user should be able to mark areas, move to other areas, and manipulates the retrieved attributes till he reaches his goal of understanding the data, and inducing new knowledge. The visualization should change rapidly and iteratively, with each interactive step the spatial representation should be rendered fast enough to allow continuous interaction.

The context-based support could further enhance the usability for diversity of users, since the context is often completely different between users. It might be even different in various situations of the same user. Context-based support is important to capture user's individual interaction pattern/interests and provide them personalized results. We believe that this could be actually more useful for the lay users as they need more automated assistance during the interaction. The real-time logging of the interaction and mapping this to models of search and interaction could reveal more about the intent of the user's search. The proposed knowledge-based support needs to represent and reason with human knowledge and formalize the intersection between interaction and knowledge construction.

In this paper we discuss our initial design to support end users for easy and effective analysis of geo-located facilities in urban areas. In future we would like to extend the current design through more exploration and interaction capabilities, and evaluate proposed visualizations though user centered approach.

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