User Profiling and Geovisual Analytics Process Modeling for Maritime Surveillance

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Abstract. Geovisual analytics is used for discovering patterns in spatio-temporal data by the way of visual interaction. But developing adequate visualization tools requires knowing the tasks and the users that will perform this data exploration. In order to benefit from geovisual analytics advances, it is necessary for maritime surveillance uses of maps to be investigated. Formalization of map uses and of user profiling lay the foundations for investigating the contribution of geovisual analytics. Then, geovisual analytics solutions are modeled to investigate the tasks they allow and the requirements of use. We propose an ontological model for user profiling and geovisual analytics solutions.

Keywords: user profiling, geovisual analytics, map uses, ontologies, maritime surveillance

1 Introduction

Visual analytics process in data exploration allows discovering patterns in data, this way creating new knowledge about the domain of interest [1], such as public safety & security. Within maritime domain, visualization plays a major role in surveillance systems. With these systems, perators and analysts constantly visualize spatial and temporal data at sea. But this simple display of data does not provide advanced analysis tools for knowledge discovery and risk prediction, as general risk management would require [2]. The need of analysis methods and the will of keeping control on maritime data by human operators led us to investigate geovisual analytics.

To develop new geovisual analytics solutions, the uses of maps in maritime surveillance and the skills of users have to be analyzed. Indeed, complex information visualizations for anomalies detection can be too complex for operators, which would complicate the ease and effectiveness of tasks [3]. For this reason, modeling the contribution of geovisual analytics to maritime surveillance tasks is a major step toward developing adequate visualization methods for monitoring traffic at sea.

We investigate here map uses in maritime surveillance. Uses and users profiling for maritime surveillance systems are described. Then geovisual solutions are formalized, to investigate their contribution to map uses. We use an ontology to implement this model.

2 Modeling Maritime Risks for Enhanced Surveillance

Along various projects and interviews, we observed that user trust a system better if he understands the patterns, by keeping visual control of monitored space. To keep this philosophy of analysis, the use of geovisual analytics is of major importance to improve surveillance at sea [2, 4]. Though automated process like data-mining [5] or Bayesian network [6] may provide more results in a shorter time, for anomalies detection and help in decision-making. New knowledge is then used for further information analysis, in the iterative process of risk management [2, 7]. For instance, Vandecasteele proposed spatial ontologies to automatically detect identified patterns in real-time data [8].

"Visual mining", led by human beings and aided by visual analytics environments, makes the knowledge discovery easier to remember and improves patterns recognition [9]: there is less "black-box" effect and cognition in maps in enhanced. Recent works of Riveiro [4], Willems [10] and Hurter [11] proved that geovisual analytics environment improve detecting patterns and anomalies in traffic data. Though these tools may require advanced skills in statistics or information visualization. Before proposing new geovisual analytics solutions for maritime data exploration, the uses of maps and the various user profiles have to be investigated.

3 Maritime Uses of Maps and User Profiling

Past few years of research showed that the use of geovisualization strongly depends on user's profile, his background and his skills [12], but also on the tasks to be performed with maps [13]. Taxonomy for the use of maps and visualization is crucial for investigating adequate geovisual solutions [9].

From two events of interest in maritime surveillance (parallel fishing and stop at sea), we identified questions for spatio-temporal data exploration that should be investigated with the use of maps and complementary diagrams. We listed these questions within 4 successive steps in data exploration: *General identification*, *Spatio-temporal analysis*, *Context analysis* and *Risk interpretation*. These groups of questions are similar to the steps defined by Kimerling et al. [14]: map *reading*, map *analysis* and map *interpretation*. Task primitives have then been identified for these exploration questions, which stand for the tasks in map use. For instance the question *How long was this event in space?* corresponds to *Measure time* task. These primitives will be used later for identifying the contribution of geovisual analytics solutions.

Identifying these tasks led us to consider general uses of maps in maritime surveillance, among which were uses of interest for geovisual analytics: *Monitoring* and *Analyzing*. Monitoring deals with real-time data and detecting patterns, which would prevent known dangerous events. Analyzing deals with historical data, deep exploration of events and context for extracting new patterns. Analysis requires highest interaction with the data for exploring a specific event: understanding the context of an event would then improve the monitoring.

To characterize the way users would deal with these tasks, significant attributes have been identified. *Profession of user*, *Education level*, *Knowledge of the data*, *Technological abilities* are intrinsic characteristics for user. These would influence the uses in the task execution. According to the task, time pressure is also a decisive factor for choosing visualization solutions. But this last characteristic does not depend on the user.

Various users have been modeled in our ontology, and divided into general concepts such as *Maritime users* or *Academic users*. Figure 1 illustrates the concepts used in the ontology and the properties for modelling the user. For each concept, value has to be chosen within 3 possibilities (equivalence between the concept and the set of 3 values).

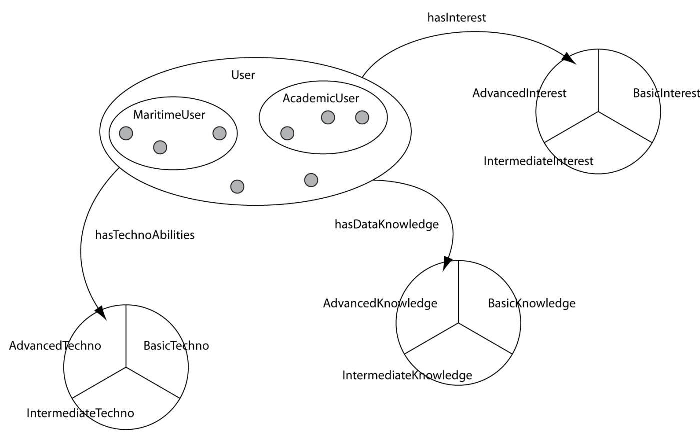

Fig. 1. User profiling model

4 Formalizing Geovisual Analytics Solutions

Once the uses of maps and user characteristics have been identified, the following step is to formalize the possible geovisual analytics solutions that are adequate to the tasks and data. We investigate here the "stop at sea" event.

A stop can be visualized by many ways, but only a few methods will be correctly adapted to the user's skills and the tasks to be performed. If the use requires near real-time mapping with many ships to display, a space-time cube [15] would not be the most adequate visualization because of the many trajectories. Among dozens of ships, the most important information is the stop: locating it and measuring its duration. Visualizing the stop event with a proportional symbol is efficient to answer these two questions *WHERE* and *HOW MUCH*. If the task requires comparing duration of stop to duration of total travel of moving object, a space-time cube is a possible solution as the time is represented in a third dimension.

Ed Chi developed the Data State Reference Model [16] to model visualization methods, by describing the successive transformations of the data and possible interactions from data space to visualization space. Daassi et. al [17] improved this model to include temporal data visualization. Based on this framework, we modeled geovisual analytics solutions to compare input data, visualization space, context information, etc. Figure 2 illustrates chosen concepts used in the ontology for describing geovisual analytics solutions. This model allows comparing geovisual solutions for the use. Later, the user's evaluation will allow validating the use of these solutions, according to their tasks.

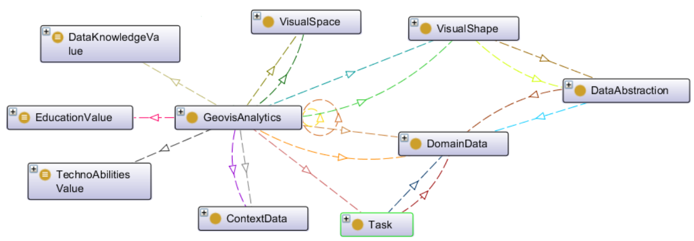

Fig. 2. Geovisual analytics model onotlogy in Protégé

5 Conclusion & Future Work

Geovisual analytics provide various means of analyzing space and time data, attributes and context information. But in risk management, such as maritime safety & security, the most adequate solutions have to be used to enhance data exploration. For this, uses of maps and user abilities are taken into account for proposing adequate solutions.

This study showed the methodology used for profiling maritime users and modeling geovisual analytics process. Users of maritime surveillance systems are at the center of visual analytics: next work will consider their evaluations to validate and to improve this model. The ease of use and usefulness of solutions will be tested regarding various tasks, solutions and controls.

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