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GeoVisual analytics, time to focus on time

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This issue of *Information Visualization* showcases research activities related to dealing with *time* in geovisual analytics. It represents a selection of the contributions made to a dedicated scientific workshop coordinated by the *International Cartographic Association (ICA) Commission on Geovisualization*.

Theoretical and methodological approaches to exploring and analyzing large complex datasets with spatial and temporal components were presented, discussed, and developed at the meeting entitled "GeoVisual analytics, time to focus on time" in Columbus, Ohio, which was held on 18 September 2012, one day before the GIScience 2012 conference. The high levels of interest raised by the workshop indicate that this theme is very important and that many scientists and research teams are occupied with the challenges that it raises. This corresponds to the growing interest in time-referenced data in information visualization and visual analytics research.[1] It also indicates that spatiotemporal data pose plenty of research problems. Most of these are complex and addressing them effectively requires cross-disciplinary approaches. This has been reflected not only in the contents of the submissions but also in the composition of the workshop attendees, including participants with backgrounds in geography, geographic information science, information visualization, and knowledge discovery.

Geospatial visual analytics has a tendency to emphasize the spatial components of geographic information. At this workshop, we encouraged approaches that integrate visualization with data mining, database processing, optimization, and other computational methods for utilizing and emphasizing the temporal characteristics of geographic information in rich, novel, and useful ways—"it's time to focus on time."

The workshop was continued in a series of successful Commission workshops on

- Visualization, Analytics, and Spatial Decision Support at GIScience 2006;
- Geovisualization of Dynamics, Movement, and Change at AGILE 2008;
- GeoSpatial Visual Analytics at GIScience 2008;
- GeoSpatial Visual Analytics: Focus on Time at AGILE 2010.

These workshops produced a number of special issues (see the complete list at the *ICA Commission on Geovisualization* website: http://geoanalytics.net/ica) and shaped the research agenda in geovisualization and visual analytics.[2–5] These research agenda articles have substantial impact on visual analytics research as evidenced by frequent citations in the scientific literature.

Not surprisingly, the main topics of the research agenda were reflected in the workshop submissions. Figure 1 shows a wordle.net aggregated representation comprising all words of the extended abstracts submitted to the GeoVA(t) workshop. One can observe that geovisual analytics research focuses on DATA, INFORMATION, PATTERNS, DATA MANAGEMENT, and ANALYSIS METHODS.

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Figure 1. Most prominent words from all extended abstracts are summarized and visualized by the wordle.net Web service.

Workshop topics such as TIME, TEMPORAL, and SPATIOTEMPORAL are prominent in this representation. Specific types of spatiotemporal data reflecting MOBILITY, MOVEMENT, and TRAJECTORIES attract the attention of researchers and application developers, thus confirming that mobility analytics is a very important topic in visual analytics.[6] Visual analytics research is bringing analysis into practice; this is reflected in prominent keywords such as INFRASTRUCTURE, TOOLS, ARCHITECTURE, SYSTEM, FUNCTIONALITY, PROJECT, APPLICATIONS, and USERS.

The workshop and this special issue

The original call for papers for the workshop attracted 19 submissions (extended abstracts), out of which 16 were selected to be presented in Columbus in September 2012. Short abstracts and slides of all presentations are available on the following workshop website: http://geoanalytics.net/GeoVA(t)2012/.

One of the evaluation criteria for the extended abstracts was the maturity of the work and its potential for subsequent development into a journal article. The authors of the submissions that scored highly according to this criterion were invited to submit full articles in order to be considered for publication in this special issue after a full review process. Nine article submissions were received and reviewed by one of the guest editors and one external reviewer each. The outcome is the current special issue consisting of six articles, and an acceptance rate of 32% if the full procedure, from the original workshop submissions to the accepted journal articles, is considered.

We are very grateful to the reviewers and the authors for their diligent and extremely efficient work. It is notable that the reviewers not only criticized the articles but also gave concrete recommendations to the authors for their improvement through revision.

The special issue begins with the article "Feature-based automatic identification of interesting data segments in group movement data." This article considers three categories of group movement data analysis tasks based on the analysis focus: (a) movement characteristics of an individual in the context of its group, (b) the dynamics of a given group as a whole, and (c) the comparison of the behavior of multiple groups. The article proposes an approach that includes calculation of time-dependent group movement features (such as group compactness and distance from a moving object to the group center or boundary) followed by pattern detection in time series. Multiple coordinated displays enable interpretation of patterns from spatial, temporal, and group composition perspectives.

"Visual analysis design to support research into movement and use of space in Tallinn: a case study" presents a study of using the space of the city by suburban residents. Data obtained from mobile phone records provide dynamic positioning information, which is joined with land-use data to form generalized geocontext. Novel coordinated visualizations enable consideration of patterns from spatial, temporal, socioeconomic, and land-use perspectives. Interactive operations such as sorting, filtering, and brushing facilitate identification, localization, and comparison of patterns.

"Are we what we do? Exploring group behaviour through user-defined event-sequence similarity"

continues the human geography theme. The study presents a visual analytics approach for comparing individuals based on the similarity of their behavior. A collection of activity diaries has been used in the article to exemplify the approach. The dataset consists of 463 individuals' activity sequences described through 600 types of activities hierarchically classified into five levels of detail. Diaries are clustered by similarity of event sequences for investigating whether groups of individuals having similar time use patterns of their daily life are also characterized by similar demographic and socioeconomic attributes. Coordinated interactive displays enable consideration of groups of interest from multiple perspectives, including spatial, temporal, demographic, and activity patterns.

"Multi-scale analysis of linear data in a two-dimensional space" proposes a novel method for analyzing time interval data using a representation technique called the Continuous Triangular Model. This model enables representation of features related to time intervals on multiple levels of temporal resolution, providing an explicit overview of time series at multiple scales. To demonstrate the power and flexibility of the approach, the article considers two case studies. The first case study presents analysis of speeds and travel times on different sections of a highway, effectively demonstrating mobility patterns at different geographic scales and allowing comparison of representations for different time periods. The second case study combines multiple models based on different attributes for site selection problems.

"Visualizations of coastal terrain time-series" builds on existing approaches for visualizing spatiotemporal data to create a collection of cognitively informed representations that support exploration and discovery in coastal terrain evolution analysis. The coastline is converted into a linear representation, enabling the creation of a synthetic diagrams representing coastline evolution in space and time. A specially designed version of space–time cube shows simultaneously pairs of attributes such as magnitude and direction of ridge line positions. A number of interesting patterns have been retrieved from the data and visualized within their spatial and temporal contexts, including changes of shoreline, dune ridge migration, dune breaches and overwash, the formation of new dune ridges, the construction and destruction of homes, and changes that occurred due to erosion and accretion, hurricanes, and human activities.

"Interactive visual summaries for detection and assessment of spatiotemporal patterns in geospatial time series" proposes a method for detecting similar situations from spatial time series data, such as spatial distributions of climate variables. Initially, hierarchical clustering groups all time steps of a geospatial time series into a hierarchy of clusters. Users can interactively explore this hierarchy to select sets of time intervals and corresponding spatial situations. The exploration process is supported by multiple visualizations that emphasize spatial, temporal, and hierarchical characteristics of the data. The approach helps geoscientists gain a more complete understanding of geospatial time series.

A common feature of the articles is that they consider a variety of transformations of spatiotemporal data, look at data from multiple perspectives, and propose novel visual analytics techniques that are capable of empowering users to leverage large complex datasets in solving practical problems. Enabling transformations and multiple representations of data is becoming a common trend in visual analytics in the space–time domain,[7] and the research presented here provides a variety of means through which this may be achieved in a number of pertinent contexts.

We hope that these articles will be interesting and useful not only for people primarily occupied with analysis and/or visualization of spatial data but also for more general readers as they search for effective technical and graphical means of representing and analyzing their large spatiotemporal datasets.

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