ATLAS: A Framework for Geospatial Visualization

Extended Abstract†

Nathan Matteson
DePaul University
Chicago
IL
U.S.A.
nmatteso@cdm.depaul.edu

Dalavone Keoborakot
DePaul University
Chicago
IL
U.S.A.
ninakeoborakot@gmail.com

Madeline Grodek
DePaul University
Chicago
IL
U.S.A.
madelinegrodek@gmail.com

Camille Celone
DePaul University
Chicago
IL
U.S.A.
camille.celone@gmail.com

ABSTRACT

Due to technological advances in data collection and distribution methods, data is increasing in size and complexity. Challenges and opportunities have emerged in the design of data visualization tools, particularly in the visualization of geospatial and multidimensional data. Traditional visualization approaches are falling behind as they lack effective design solutions for usability issues posed by the complex relationship between spatial and numeric data. Interdisciplinary approaches are essential to address issues in geovisualization, thus the field of human–computer interaction can act as a useful lens upon the problems of data discovery within seemingly disparate fields such as climate and agricultural sciences. ATLAS is a tool for the discovery and visualization of multidimensional geospatial data (MDGSD) and aims to aid data discovery. It proposes a new approach to the visualization of MDGSD: creating a single, 'multi-modal' interface for both spatial and time-series information. Benefits and failures inherent in this approach were identified though user testing. Tests were administered to nine college students pursuing various fields of study. Preliminary analysis of data suggests that participants recognize a relationship between the spatial and time-series information; however, subjects disagreed about the significance of colors across them. Our future work aims to utilize eye tracking data to determine whether data discovery is successfully enabled in ATLAS by examining how participants visually assess and connect the data. ATLAS offers insight on the emerging opportunities of interdisciplinary work in human-computer interaction and data visualization.

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1 INTRODUCTION

This study explores ATLAS, a tool for the discovery and visualization of multi-dimensional geospatial data (MDGSD). Contemporary MDGSD presents a variety of problems for visualization—data complexity has reached a point where current methods of visualization cannot clarify the relationships among spatial and temporal data. MDGSD blends problems from both geographic and non-geographic domains, so that interdisciplinary approaches are needed to address the issues underlying successful visualization. Our solution, ATLAS, proposes improvements to a rarely used approach to data visualization: the use of a single interface for interactive spatial and time-series data.

2 METHOD

Several existing tools for the visualization of geospatial data were examined prior to designing the ATLAS prototype. Tools such as CropScape [3] created by the United States Department of Agriculture and NASA Panoply [5] take a modal approach to visualizing spatial and numeric data. Users choose spatial data points on one screen and the tool displays graphs data along non-geospatial dimensions on a separate screen. There are different interfaces for each 'mode' of data, and disparate types of data cannot interact with one another.

We hypothesize that usability is disrupted in these disjointed, modular systems, and argue that data visualization tools will be more effective if the visualization of spatial and non-spatial data can be completed on a single interface. Our approach is to use methods from the field of human-computer interaction (HCI) to merge these disparate modes into a single 'multi-modal' user interface (UI) to better enable data discovery. HCI provides visualization tools the ability to become "more powerful and useable" [4]. The Bioenergy Knowledge Discovery Framework's (KDF) Biomass Scenario Model Tool [2] created by United States Department of Energy displays use of a similar approach by allowing users to interact with spatial and scalar data—e.g. maps and charts—on a single interface. However, KDF demonstrates limited use of this approach because the user interacts only with low resolution or aggregated data.

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While ATLAS offers features similar to those available in KDF, ATLAS allows users to interact with MDGSD in the map and time-series graphs without recreating or reloading information. This design pattern is intended to support the process of data discovery in highly dimensional datasets.

2.1 Process

The ATLAS prototype underwent several iterations before reaching a final design pattern for displaying MDGSD. Initially data was exclusively displayed on a map with a legend relating sets of values to colors on the map. In the second iteration, statistical values appeared in a pop-up when users clicked on a datapoint on the map. Since visualizations of abstract constructs "require sophisticated methods, tools, and user-system interaction facilities for their exploration and analysis," [1] the addition of the pop-up allowed users to obtain more information for data discovery to occur. Furthermore, the pop-up offered the option to download data over time for the selected region. The third iteration replaced the pop-ups with graphs in a collapsible drawer at the bottom of the map interface.

Several map and drawer interactions were conceptualized to determine optimal functionality of the multi-modal interface. User interactions between the map and the drawer containing a time-series graph and histogram proved to be a challenging design problem as both geovisualization and HCI lack a design pattern for interactive displays of MDGSD. In the fourth prototype, all interactions including the addition of other spatial points, occur in the drawer. Informal testing of this design pattern was conducted with a group of student colleagues, and results showed that the map and drawer interactions were not intuitive to users. However, participants understood and showed appreciation towards the multi-modal interface. As a result, the map and drawer interactions were refined in the final iteration: the map controls the addition and subtraction of points in the graph while the drawer controls interactions with the selected region.

2.2 Prototype

The prototypes were developed in Axure RP 8 and Adobe XD CC. The interface contains a geospatial visualization and a time-series charts hidden by default in a collapsible drawer. The primary function of the prototype is to allow users to select data points on the map and view the data of the selected points as a time series graph or histogram in the drawer occupying the bottom half of the screen. Users can dynamically change the data points displayed on the graph by choosing points on the map to add or remove.

2.3 User Testing

User testing was administered to nine college students pursuing various fields of study. Participants completed interview questions and seven tasks on the ATLAS interface. We collected qualitative, quantitative, and eye tracking data. While HCI employs the use of well-defined tasks to measure user success, geovisualization does not possess similarly defined scenarios, thus goal achievement is difficult to measure [4]. Our goal was to gauge the usability of the interface and understand the effectiveness of the color schemes between the geospatial and time-series interfaces—the former using categorical color marking, the latter using ordinal, though both sharing the same palette of hues.

3 RESULTS

Preliminary analysis of data suggests that participants recognize a relationship between the geospatial and time-series information. However, subjects disagreed about the significance of color usage across them. Furthermore, a majority of participants failed to understand that events in the graph drawer affected the map, and that the data legend was interactive.

4 FUTURE WORK

We will be using eye tracking as a proxy for making plausible inferences about the occurrence and level of success of data discovery in ATLAS. Masks of the UI with regions weighted by relevance to each task will be used to distinguish productive eye movements from misfires. The product of the relative weight of each fixation and the length of saccade between them will allow us to make inferences about the clarity of visual connections between the various components of the interface. These custom metrics combined with other common eye tracking metrics such as measures of gaze and saccade size will provide a reasonably fine-grained view into the efficacy of the platform.

We plan to implement our design pattern on an accessible in-browser visualization tool with D3.js and Vue.js. This will enable us to receive feedback from a larger group of users, build comparisons of ATLAS to similar platforms like Panoply, CropScape, and KDF, and make our findings and design pattern accessible to the public.

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