Geovisual Analytics and Storytelling Applied to a Flood Scenario

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1 INTRODUCTION

The large and ever-increasing amounts of multi-dimensional, multi-source, time-varying and geospatial digital information represent a major challenge for the analyst. The need to analyse and make decisions based on these information streams, often in time-critical situations, demands efficient, integrated and interactive tools that aid the user to explore, present, collaborate and communicate visually large information spaces. This approach has been encapsulated in the idea of Geovisual Analytics, an interdisciplinary field that facilitates analytical reasoning and decision making through integrated and highly interactive visual interfaces and creative visualization of complex and dynamic data. Geovisual analytics supports geo-information for emergency and early warning systems through a science that augments analysts and decision-makers capabilities to assimilate complex situations and reach informed decisions. In this context, we introduce a geovisual analytics system applied to a flood scenario. The system is aimed at supporting planners, policy makers and insurance companies to explore the data of a flood event, estimate the damage caused by the flood event to buildings and make plan for rescuing or evacuating people. The system is developed in close collaboration with our research partners and domain experts from SIM (http://www.sim.ul.pt/) and UNINOVA (http://www.uninova.pt/) and focus on the analytics reasoning aspects enabling analysts to explore spatial, temporal and multivariate data from multiple perspectives simultaneously using dynamically linked views, discover important relationships, share their incremental discoveries with colleagues and finally communicate selected relevant knowledge and publish early warnings if required. These discoveries often emerge through the collaboration between expert domains and operators with diverse backgrounds and are precious in a creative analytics reasoning process.

2 DATA

Flood data is simulated based on a real flood event taking place on 29 October 2010 in Lisbon [1]. It is simulated for a period of 4 hours with the time resolution of 10 minutes on an area of 3.2km x 3.6km in Lisbon downtown. The data is provided in a format of a grid of cells in which each cell has the size of 4.5 m x 4.5 m. Each cell has a series of values which represent the water-columns at that cell over time. Other inputs include a map of buildings and formulas provided by experts from SIM for estimating the damage caused by the flood event to buildings. The formulas are developed from the point of view of an insurance company. The damage to each building is calculated based on (1) the water-column surrounding the building, and (2) the types of the building. More information about the formulas can be found at [2]. All data used in this research is provided by SIM.

3 APPROACH

The system is developed based on the GAV framework [3]. A multiple coordinated linked views approach is used to allow the user to view data from different perspectives. A map view is selected as the central view of the system. To visualize flood data, a grid layer is developed and added into the map component of the GAV framework. Grid cells are coloured according to their water columns. A colour scheme is designed based on the suggestion of the domain experts from SIM. It ranges from white blue, blue, green, and orange colour to red and dark red colour. The dark red colour indicates a high value of water column and the white blue colour indicates a low value of water column. An animation controller is used to allow the user observe the progress of the flood event over time. The user can also use the time slider to move back and forth in time dimension to explore the flood data of any time period.

A building layer is implemented for visualizing the buildings. Based on the flood data, the data of buildings on a number of indicators are calculated. For example, for each building, the intersection between the building and the flood grid is calculated. This results in a list of cells which intersect with the building. The water columns at these cells are then used to calculate the average water column surrounding the building. This value, in turn, is used to calculate the constant damage to the building. The accumulated damage to the building is calculated based on constant damage values.

To allow the user to explore and analyse the flood data and the damage to buildings, a number of interactive visualizations are added into the system and linked to each other to enhance the performance of analysis. They include

- a time graph for supporting the analysis of time series data of selected grid cells such as water column;
- a time graph for supporting the analysis of time series data of selected buildings such as average water column, constant damage, accumulated damage; and
- a bar chart, a scatter plot, and a data table for supporting the analysis of attribute values of all buildings;

The system inherits the component-based architecture of the GAV framework; therefore, it can be extended further with other interactive visualizations from the GAV framework. The system also exploits a dynamic layout architecture which allows the user to resize views, move around views, maximize or restore views.

To facilitate visual exploration processes, the system implements and inherits various interaction techniques from the GAV framework. For example, in addition to common map interaction techniques such as single selection, multiple-selection, tooltip, hovering, the system also implements rectangle-selection which allows the user to select an area of cells on the map by dragging-and-dropping. When cells are selected in one view, they are highlighted in all linked views through the selection-based linking mechanism. Similarly, when buildings are selected in one view, they are highlighted in all linked views. If they are selected from a view which is not the map view, these buildings are brought into the centre of the map view to allow the user quickly identify them on the map. Furthermore, all cells intersecting with selected buildings are also selected and highlighted in all linked views.

To support users such as analysts or planners interact further with the map and collaborate with other users in analysis of data and making plan, the system implements a number of dynamic map layers. The first layer is a marker layer which allows the user to be able to interactively mark special locations or locations of interest. The second layer is a polyline layer which allows the user to draw routes and measure the distance between locations. The distances between locations in a route are displayed along the route. The third layer is a note layer which allows the user to put notes on the map. The notes can be interactively moved around the location to which it links. The width of a note can be interactively resized, but the height is automatically calculated to fit the content of the note. The forth layer is a traffic route layer which allows the user to find traffic routes based on the same feature of online maps such as Google map, Bing map, or OpenStreetMap. Each of these layers has a setting panel which allows the user to (1) change its property values such as colour, opacity, scale, (2) show or hide the layer, (3) show or hide items of the layer, and (4) delete items from the layer. For example, after putting a note on the map, the user is able to remove this note from the map.

In addition to these layers, the system also implements a hyperlink layer which mark buildings which have a link to an external source (e.g. a website describing the architecture of a building or information about the building). Figure 1 illustrates a number of map layers of the map view.

To facilitate switching among various interaction techniques, a right-click context menu is implemented which includes different commands for different interaction techniques.

To support the user to be able to share and communicate gained insights to other users, an important step in a collaboration process, the system inherits the snapshot mechanism and the storytelling technique of the GAV framework. It implements the snapshot mechanism for the new map layers added into the map component.

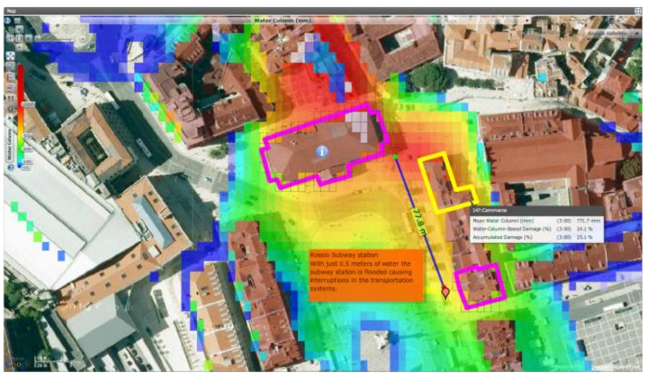

Figure 1. An illustration of a number of map layers of the map view

4 Result

The system has been used to analyse the flood data which simulates the real flood event taking place on 29 October 2010 in Lisbon. The result of an analysis process shows that S. José Street is one of the most affected streets by the flood event where the water goes up to 1 meter height after 1 hour 50 minutes (see Figure 2). The damage caused by the flood event (under the given formulas) to a number of buildings along this street goes up to 19% of the total value. Similarly, the area around the National Theatre D. Maria II is one of most affected areas by the flood event. After 2 hours 10 minutes the floodwater in this area reaches the maximum value of 1.2 meters height, and the theatre is surrounded by floodwater in every direction (see Figure 3). The damage caused by the flood event (under the given formulas) to the theatre is about 21% of the total value.

5 User feedback

The system is put online at [4] and has been evaluated by three users. After one hour learning the system, one user from SIM has produced a short story [5] presenting his gained insights into the flood data and shared it with the two other users and the authors of this paper. A number of telecom meetings with the users are done through skype to gather their feedback. The general feedback is positive. Many features are listed as helpful techniques such as linked views, animation. Highly evaluated features include (1) note-making, (2) distance measuring, and (3) the storytelling technique for presenting gained insights. Some new features are suggested: (1) the ability to dynamically update the formulas, (2) map layers representing police stations, schools, and (3) the ability to export a subset of data of interest.

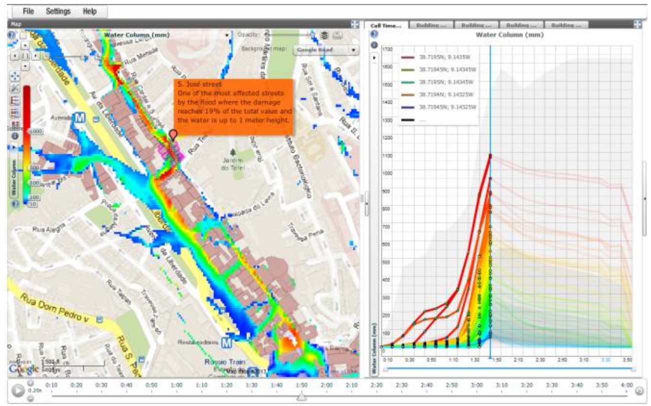

Figure 2. S. José Street is one of the most affected streets where the floodwater goes up to 1 meter height after 1 hour 50 minutes.

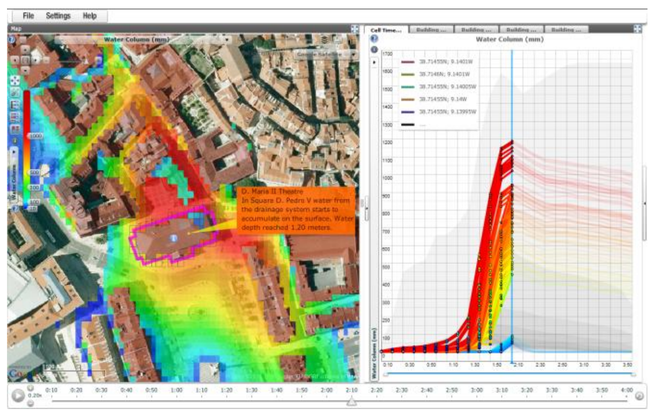

Figure 3. The area around the National Theatre D. Maria II is one of the most affected areas where the floodwater reaches the maximum value of 1.2 meters height after 2 hour 10 minutes.

6 Conclusion

This paper introduces a system developed based on geovisual analytics approaches for a flood scenario. The system is a combination of various geovisual analytics techniques: multiple coordinated linked views, interactive map techniques (e.g. note-making, route planning, and distance measuring), snapshot mechanism, and storytelling. The system has been evaluated and received positive feedback.

References

[1] Flood event : http://www.youtube.com/watch?v=bhd23XKHjCM
[2] Formulas: http://vitagate.itn.liu.se/GAV/flood/formulas/
[3] Quan Ho, Patrik Lundblad, Tobias Åström and Mikael Jern. A web-enabled visualization toolkit for geovisual analytics. *Journal of Information Visualization*, Vol. 11(1): pp. 22-42, 2011.
[4] Online flood demo: http://vitagate.itn.liu.se/GAV/flood/
[5] Online flood demo: http://vitagate.itn.liu.se/GAV/flood/story/