Developing a Real-time Situation Awareness Viewer for Monitoring Disaster Impacts Using Location-Based Social Media Messages in Twitter

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ABSTRACT

Collecting real-time social media messages along with videos, pictures, and hashtags during disaster events might help first responders and incident commanders improve their situation awareness and identify potential risks and problem in the field. GeoViewer is a web application for monitoring real-time social media messages in selected areas during disaster events. By using free open source programming libraries and databases, GeoViewer can help us visualize and query location-based tweets from a NoSQL database and provide interactive mapping and spatial query functions.

1. Introduction

Situation awareness plays an important role in disaster response, recovery and emergency management. Collecting real-time social media messages along with videos, pictures, and hashtags during disaster events might help first responders and incident commanders evaluate ground truth effectively (Tsou & Leitner, 2013; Reuter et al. 2014) and identify potential risks and problem areas during their rescue efforts. There are several good examples of using social media messages for emergency management, including the 2010 Haiti Earthquake, 2013 Typhoon Haiyn in the Philippines, and the 2014 Ebola outbreaks in West Africa (Moore and Verity, 2014). However, most of previous examples are lacking of integrated, user-friendly web applications to collect relevant location-based social media messages, pictures, and videos in real-time.

The Center of Human Dynamics in the Mobile Age (HDMA) at San Diego State University is collaborating with the San Diego County Office of Emergency Services (OES) to develop a real-time web application, called Geo-targeted Event Observation (GEO) Viewer, or GeoViewer (http://vision.sdsu.edu/hdma/wildfire/). GeoViewer is designed for improving real-time situation awareness for incident commanders and decision makers during disaster events. The collected geo-tagged messages, videos, and pictures in GeoViewer can provide valuable information for disaster management tasks, such as disaster warning messages, evacuation orders, road closure decisions, or responder dispatch tasks.

The design of GeoViewer follows the concept of pragmatic map design in cartography, which emphasizes on providing the most important (and simplified) information for map readers effectively with an easy-to-use user interface and data analytic functions. GeoViewer is a web-based map application with a live feed to monitor the ground truth in selected topics at selected regions. GeoViewer can map both historical and real-time social media messages with powerful geovisualization/mapping functions, including hotspots and cluster maps.

The early prototype of GeoViewer was developed in Fall 2014 to display GPS-tagged Twitter messages during the San Diego Wildfire 2014 in May 2014. The prototype displayed only archived GPS-tagged tweets collected during the wildfire event associated with wildfire names, such as Cocos Fire, Carlsbad Fire, and San Marcos Fire. The real-time GeoViewer is under development now by using Twitter's Streaming Application Programming Interfaces (APIs). This extended abstract will introduce the key mapping functions and user interface design of the GeoViewer prototype. Some spatiotemporal analytics were conducted manually in this study. We are planning to add these spatiotemporal analytics into the full version of GeoViewer soon.

2. User Interfaces and Key Functions of GeoViewer

Different from traditional web GIS maps, the design of GeoViewer need to consider the interactive display of multimedia content (pictures, videos, text messages, hastags) and maps together (Figure 1). The web-based user interface (front-end) is built by using free open source programming libraries, jQuery and Leaflet APIs, to visualize and query tweets from a server-side database (back-end). In our server, over 400 San Diego Wildfire tweets were filtered and stored in a MongoDB database. MongoDB is an open-source and NoSQL database which can provide high performance query and supports spatial query from a very large datasets. MongoDB is one of the most popular databases for Big Data. We also used Python programs to create a filter procedure to remove retweets (RT) and tweets with URL (from web media).

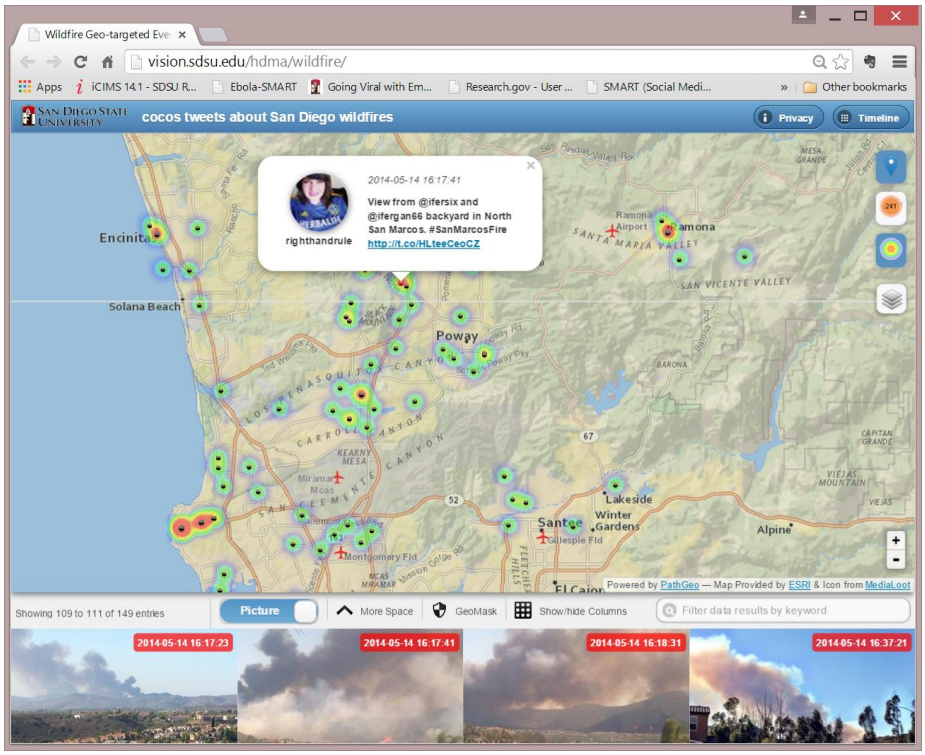

Figure 1. The mutlimedia map display of social media messages in GeoViewer.

When users access GeoViewer, they will see a timeline view first to show the major wildfires in San Diego in 2014 (such as San Marcos, Carlsbad, or Rancho Bernardo). Then users can select one wildfire event and enter the actual user interface of GeoViewer. GeoViewer provides multiple windows to display maps, pictures, and text messages from tweets. Users can click one button to switch the view between pictures and text messages (Figure 2). The

cluster of tweets or hotspots will be automatically highlighted by using kernel density maps. The gallery of pictures can help emergency management officers to monitor ground truth. To protect user privacy, we implemented a geo-masking function (i.e. concealing user location by randomly selecting a new location within a 100 meter radius) to protect the privacy of twitter users.

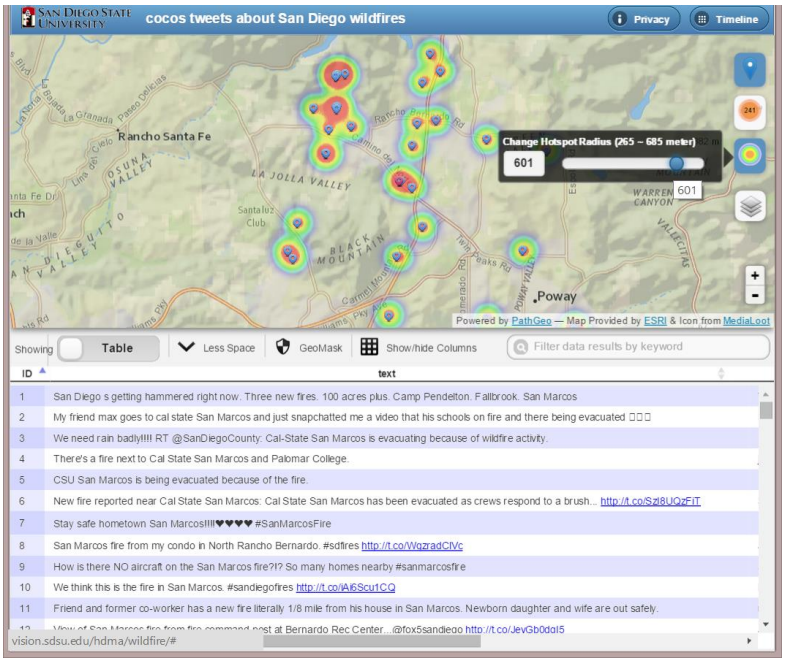

Figure 2. The switched view of Table (text messsages) in GeoViewer.

3. Spatiotemporal Analytics and Visualization

In addition to the web-based GeoViewer, we also conducted several spatiotemporal analysis tasks for San Diego Wildfire tweets. Figure 3 illustrated the temporal trend of "Evacuation" tweets collected in San Diego during the wildfire event. The left side graph is the hourly trend graph (each day shows different color) and the right side graph is the daily trend analysis. The frequency of tweets containing "Evacuation" keywords matches the actual wildfire event (starting on May 13, 2014) very well.

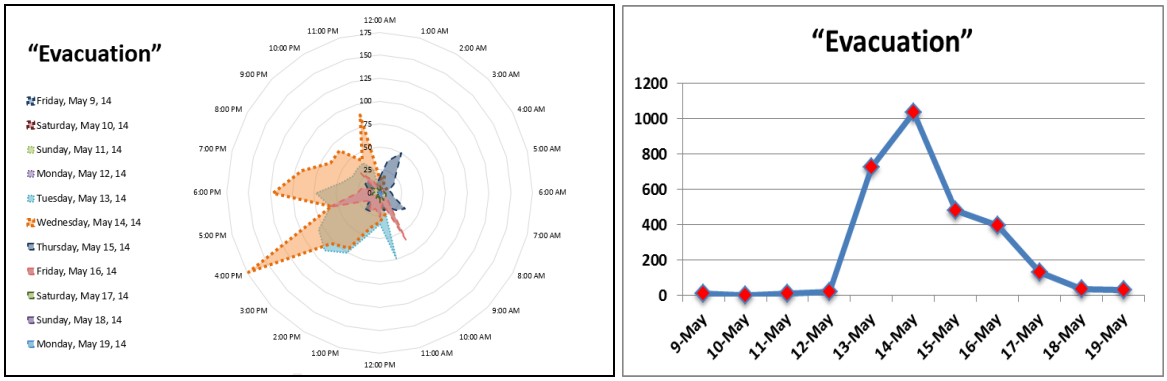

Figure 3. Temporal trend analysis of tweets containing "Evacuation" keywords during 2014 San Diego Wildfire event.

Figure 4 illustrated a dynamic spatiotemporal patterns of GPS-tagged wildfire tweets during 2014 San Diego Wildfires. The hotspots (clusters) spatial pattern of tweets on May 14 is very different from the pattern on May 15 and May 16. We found out that these hotspots are cooresponding to the actual locations of wildfires very well. This indicates that people are more likely to post tweets if they are close to the actual wildfire locations. More location-based social media messages nearby the wildfire locations can be collected for emergency management.

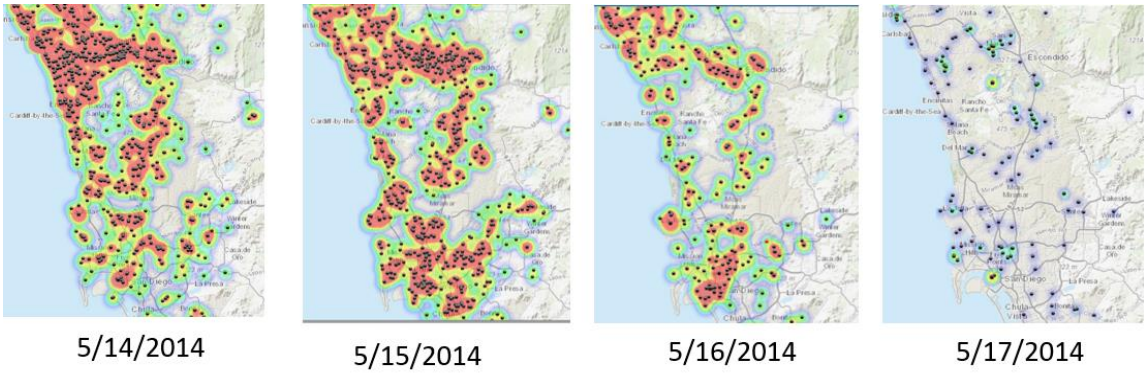

Figure 4. Dynamic spatiotemporal patterns of GPS-tagged wildfire tweets during 2014 San Diego Wildfires.

4. Conclusion

Emergency response and rescue is a critical phase in disaster management (Tsou & Sun, 2007). Real-time social media analytics can play an important role in evacuation, dispatch and vehicle tracking tasks for incident commanders and first responders (Humanity Road & Statistics Without Borders, 2014). By combining GIS mapping functions with social media analytics, GeoViewer can help firefighters, police officers, government staff to monitor and report situation awareness immediately. Several future improvement tasks for GeoViewer are 1. combining multiple map layers dynamically by other web amp services, such as wildfire perimeters, census data, vegetation, schools, etc.; 2. Real-time spatiotemporal analysis and visualization functions; 3. smart data filter and sentiment analysis functions using machine learning methods.

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