Temporal data representation on mobile devices for in-field law enforcement

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Abstract
Law enforcement operations produce and consume temporal data. Presenting such data on portable devices to enable in-field decision making is challenging. In this paper, we present a classification of law enforcement operations based on their task requirements and response times followed by a discussion of issues in temporal data representation for each task type.

Keywords
Temporal data visualization, mobile visual analytics, mobile emergency response, in-field response and investigation

ACM Classification Keywords
H.5.2 [INFORMATION INTERFACES AND PRESENTATION (e.g., HCI)]: User Interfaces---User-centered design, Miscellaneous; J.7 [COMPUTERS IN OTHER SYSTEMS]: Command and control, Real time; I.3.6 [COMPUTER GRAPHICS]: Methodology and Techniques---Interaction Techniques.

Introduction

Temporal data representation and interaction on mobile devices presents unique challenges arising due to the limited form-factor and situational context of usage of these devices. Mobile devices have been traditionally used for personal data management to represent time-related data such as calendars and task schedules. However, with their ever-improving computational power, they are increasingly being used for critical response and investigation operations in the field [1,4,5]. These operations produce and consume temporal data from disparate sources and in various forms. While the backend representation of time-related data is similar to that of desktop based systems, client side data representation should consider the form-factor and situational constraints of the mobile device. In this paper, we specifically focus on the issues of representing time-based data encountered in in-field law enforcement operations.

In-field law enforcement operations

Tracking (people, objects), patrolling, evidence and data collection, situation monitoring and investigative analysis are some in-field operations performed by law enforcement officers that can benefit from using a mobile device for making rapid decisions. Due to varying requirements and response times for each task, combined with the device constraints, it is necessary to adapt the representation and notification of temporal data accordingly.

We classify the major task types in this domain and later discuss issues in temporal data representation for each task type.

Classification of law enforcement operations

We classified various law enforcement operations into three major categories:

- In-field response (real-time and historical data)
- In-field investigative analysis (real-time data)
- Post-event investigative analysis (historical data)

In-field response

In-field response refers to operations that involve immediate action. Such operations could result from real-time data obtained during patrolling, evidence gathering and tracking operations or from historical intelligence data. Real-time data obtained from sensors such as GPS (Geographical Positioning System) and cameras, are updated in intervals of a few seconds. For response operations, it is important to provide accurate information at the appropriate frequency using effective representation and notification cues. Real-time data can be obtained by either continuously or periodically polling for data from the sensors. However, considering the limited battery resources on a mobile device, we have to poll for data periodically while sacrificing the recency of data. Entin et al. [3] observed that users in fact perceive movements better when locations of their team members are updated periodically rather than continuously. Recent updates of information should be represented in the context of their past, so that in-field responders can track changes over time. However, considering the limited memory on mobile devices, we need to strike a balance between the amount of history stored (and displayed) and the available memory on the device. Typically, such data is displayed using ghosting techniques as used in [4] with the faded trail region indicating data from the recent past. In-field responders also may often have to turn their attention away from the device towards other activities. Given their limited cognitive resources while performing an operation, it is necessary to "push" important updates to the client in the form of audio or tactile notification cues [2] when they arrive. Such "push" based mechanism is also effective for presenting temporal or spatial context-based notifications generated by background monitoring processes from historical intelligence data.

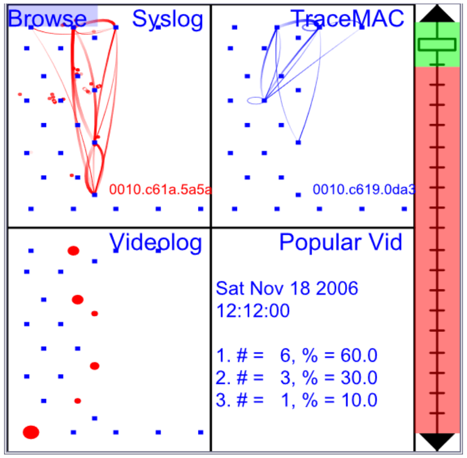

figure 1. A screenshot from the NetworkVis system [5] showing aggregated overviews of temporal data with tools for temporal analysis.

In-field investigative analysis

Investigative analysis in the field involves determining emerging trends and patterns during an event and taking appropriate action. Typically, such actions are performed by event monitors and supervisor patrols (who are responsible for the placement of their team members). Real time data is used to detect trends or anomalous patterns as the events unfold. However, such trends can be detected only after obtaining a significant amount of data. Hence the frequency of updates needs to be slower than that for in-field response. Moreover, the response time is also greater in this case. The time scale and data representation should reflect these requirements. For example, fig. 1 shows a screenshot from a system (NetworkVis) that we developed [5] to monitor and troubleshoot network activities at our university's football stadium during home game days. The system was setup to pull real-time data at regular intervals from the network log database (the green color on the timeline shows the time until when data is available). The time scale was also set to the same interval and we represented all time dependent data at two levels. The overview level shown in fig. 1 displays only the most important information aggregated from various sources (such as access points, video and game servers), to compensate for the small screen size. The second level provides detailed information upon demand and according to the analysis needs. Interacting with the timeline allows the analyst to browse through time and detect unusual patterns in the network.

Post-event investigative analysis

Post-event analysis, such as incident and crime scene analysis, is usually performed by specialized analysts in the field after an event occurs. While this type of analysis does not usually involve real-time data, it usually accesses data ranging across a broader time scale. Therefore it is important to provide temporal analysis tools at multiple granularities to discover patterns at different time scales. Moreover, it is important that the user be able to intuitively interact with and explore the data. Figure 2 shows a screenshot from a mobile system we are currently working on, which provides interactive tools to analyze crime incident reports in a small geographic region. It uses a focus + context exploration lens that also doubles up as a spatial filter for geo-tagged data. The current version just supports analysis at a single temporal granularity. We calculate simple statistics (bar graphs) on the fly to indicate number of crimes in each category. Moreover, it is also useful to display crime graphs varying with time at various granularities to provide insight into their trend variation.

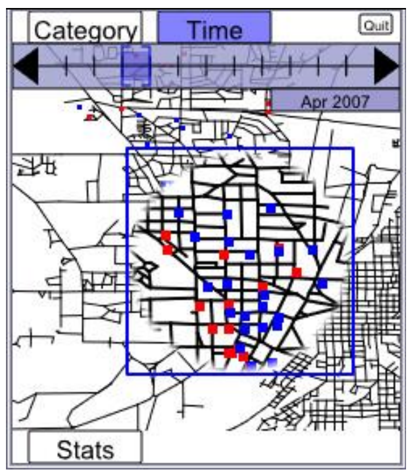

figure 2: A screenshot from our ongoing work for in-field crime incident analysis showing temporal and geospatial data

An important issue we wish to discuss in this workshop is the selection of appropriate time-scale granularities for various tasks that decide the level of corresponding data aggregation. Since this is highly task-specific, as a first step, we classified common tasks in our domain and described their temporal data characteristics. Screen space and cognitive resources are limited while using a mobile device. Therefore, data aggregated at the appropriate level should not only convey meaningful information, but also make it easily perceivable.

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References

[1] Baddeley, B., Younkin, K., Riensche, R., Best, D., Pike, W., and May, R. From desktop to field: Deploying visual incident analysis for law enforcement. In *IEEE Conference on Technologies for Homeland Security 2008,* 1-8.

[2] Campbell, C., and Tarasewich, P. Creating notification cues for mobile response teams. In *Proc. Of 2004 DSI Annual Meeting.*

[3] Entin, E. B. Representing and Visualizing a Dynamically Changing Tactical Situation. In *Proc. IEA 2000/HFES 2000 Congress,* 427-430.

[4] Kim, S., Jang, Y., Mellema, A., Ebert, D., Collins, T. Visual Analytics on Mobile Devices for Emergency Response. In *IEEE Symposium on Visual Analytics Science and Technology (VAST 2008)*, 35-42.

[5] Pattath, A., Bue, B., Jang, Y., Ebert, D., Zhong, X., Ault, A., and Coyle, E. Interactive Visualization and Analysis of Network and Sensor Data on a Mobile Device. In *IEEE Symposium on Visual Analytics Science and Technology 2006,* 83-90.