Visualization in Law Enforcement

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ABSTRACT
Visualization techniques have proven to be invaluable in crime analysis. By interviewing and observing Criminal Intelligence Officers (CIO) and civilian crime analysts at the Tucson Police Department (TPD), we identified two crime analysis tasks that can especially benefit from visualization: crime pattern recognition and criminal association discovery. As part of an extension to the COPLINK project [1], we have developed two systems to provide automatic visual assistance for these tasks. The Spatial-Temporal Visualization (STV) system assists in identifying crime patterns by integrating a synchronized view of three visualization techniques: a GIS view, a timeline view and a periodic pattern view. The Criminal Activities Network (CAN) system extracts, visualizes and analyzes criminal relationships using spring-embedded and blockmodeling algorithms. We present the functionalities of the STV and CAN systems in the demonstration section.

Categories and Subject Descriptors
H5.2 User Interfaces: GUI

General Terms
Security

Keywords
Spatial and temporal visualization, crime network, association network, social network analysis, law enforcement, crime analysis.

1. INTRODUCTION
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Two purposes for which the field of law enforcement can use visualization techniques are crime pattern analysis and criminal association discovery. In crime pattern analysis, the temporal and spatial attributes of criminal events are studied and used as the basis for formulating plans to interrupt patterns of crimes. Criminal association discovery involves using various data sources, such as police reports, national criminal databases, and vehicle records to discover associations in order to find investigative leads and build conspiracy cases. Very few applications, however, currently exist to support these functions.

The Spatial-Temporal Visualization (STV) and Criminal Activities Network (CAN) tools were designed for these purposes. STV (Fig. 1) enables crime analysts to identify crime patterns by examining the same data from three different views simultaneously. STV is currently used for crime analysis by the Tucson Police Department (TPD). CAN (Fig. 2) automatically extracts and visualizes criminal association networks from the COPLINK [1] system to help crime analysts understand and analyze these networks efficiently. COPLINK is an integrated information and knowledge management environment for law enforcement. A prototype for COPLINK was initially developed at the University of Arizona's AI Lab in collaboration with the TPD and Phoenix Police Department (PPD). It was then commercialized by Knowledge Computing Corporation (KCC) and deployed in approximately one hundred law enforcement agencies nationwide.

2. STV: PATTERN IDENTIFICATION VISUALIZATION
The current incident-visualization procedure used in law enforcement agencies such as TPD is labor-intensive and provides visual assistance for identifying spatial patterns while ignoring temporal attributes. To enable CIOs to identify additional patterns, STV integrates three visualization techniques: a GIS view, a timeline view and a periodic pattern view. The GIS displays incidents on a map for spatial analysis, the timeline displays incident density with respect to time, and the periodic pattern displays patterns with respect to time. These three views are synchronized and controlled by the central time-slider that illustrates global time bounds and the current time window. The combination of these three different and complementary views allows users to examine the same data from various angles and to identify possible patterns quickly. STV visualizes electronic police reports extracted from the COPLINK system where these reports are carefully dated and geo-coded.

The GIS uses ESRI software (http://www.esri.com) to display a map of the city of Tucson on which incidents are plotted as points color-coded by crime type. Additional maps such as public facilities may be loaded optionally. The user may also apply a geographical bound by dragging a box around an area of interest; incidents outside of the bound will be disregarded by the timeline

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and periodic pattern views. The periodic pattern view provides CIOs a quick and easy way to identify temporal crime patterns. Incidents in this view are summarized by the crime type and granularity selected by the user, allowing analysts to see different patterns develop over different time periods. The timeline view is a two-dimensional timeline with a hierarchical display of the data as a tree. The hierarchical tree organizes incidents into folders that represent crime types. The right column of the timeline view uses a block of color to represent the location of an incident in the time dimension. The overlap of incident blocks indicates crime density, which helps analysts identify crime clusters.

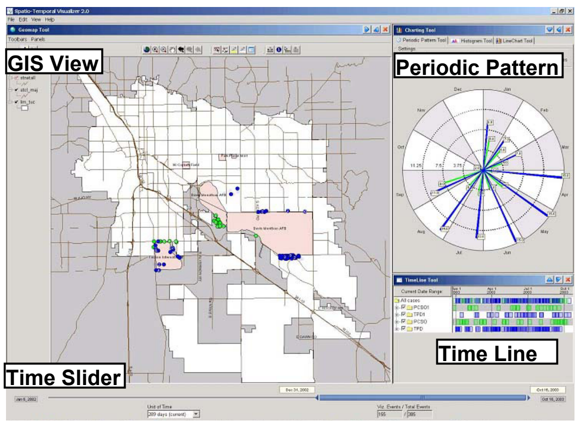

Figure 1. Major components of STV

3. CAN: ASSOCIATION DISCOVERY VISUALIZATION

A well-established criminal association network can be used by law enforcement to discover conspiracies, build investigative leads, and illustrate conspiracy cases to a jury in a court of law. Currently these criminal associations are drawn by crime analysts, either manually or with off-the-shelf software. Gathering criminal associations and drawing a link chart, however, is a tedious and time-consuming process. To accelerate the analysis process, the CAN system attempts to cover the entire crime network analysis lifecycle from network extraction to network editing, navigation and analysis.

CAN extracts association networks by automatically searching police reports. It currently supports six types of entities including people, vehicle, weapon, location, business and phone number, and five types of relations including family, friends, criminal records, phone tabs, and miscellaneous. In addition to network extraction, criminal investigation relies heavily on undocumented domain knowledge. CAN supports network manipulation functions such as (1) adding and removing entities and associations in the network, (2) creating virtual groups of entities that share similar characteristics, and (3) filtering the network to reduce information overload. CAN's network navigation component provides comprehensive navigation functions similar to a GIS system. It first renders the association network onto a two-dimensional map using a customized spring-embedded algorithm. Crime analysts can zoom and pan the viewable area of the network to gain a birds-eye view and thus not miss details. When facing a complicated association network, the crime analyst can perform a keyword search on the items in the network and bring the investigation target to the center of the view area. To help capture critical associations, a social network analysis algorithm is integrated into the system to identify criminal clusters. Social network analysis includes two steps: cluster recognition and structural analysis. The cluster recognition process is done by a reciprocal nearest neighborhood-based complete-link algorithm. The key approach of structural analysis is blockmodeling [2] to discover the roles of each entity in the cluster such as leader, outlier or gatekeeper.

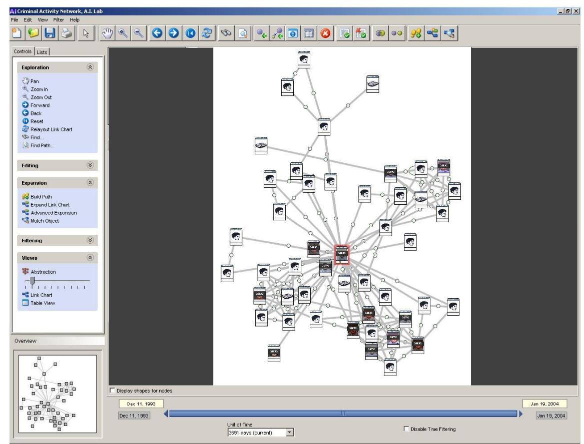

Figure 2. CAN system screenshot

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