VACCINE

Visual Analytics for Command, Control and Interoperability Environments
A U.S. Department of Homeland Security
Science and Technology Center of Excellence

VACCINE ANNUAL REPORT – YEAR 4
Addendum C - Flyers/Additional Documents
April 1, 2012 – June 30, 2013

Cooperative Agreement No. 2009-ST-061-CI0001

PURDUE UNIVERSITY

HOMELAND SECURITY UNIVERSITY PROGRAMS
TODAY'S RESEARCH & EDUCATION, TOMORROW'S SECURITY

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Jigsaw: Visual Analytics for Investigative Analysis on Document Collections

School of Interactive Computing
Georgia Institute of Technology

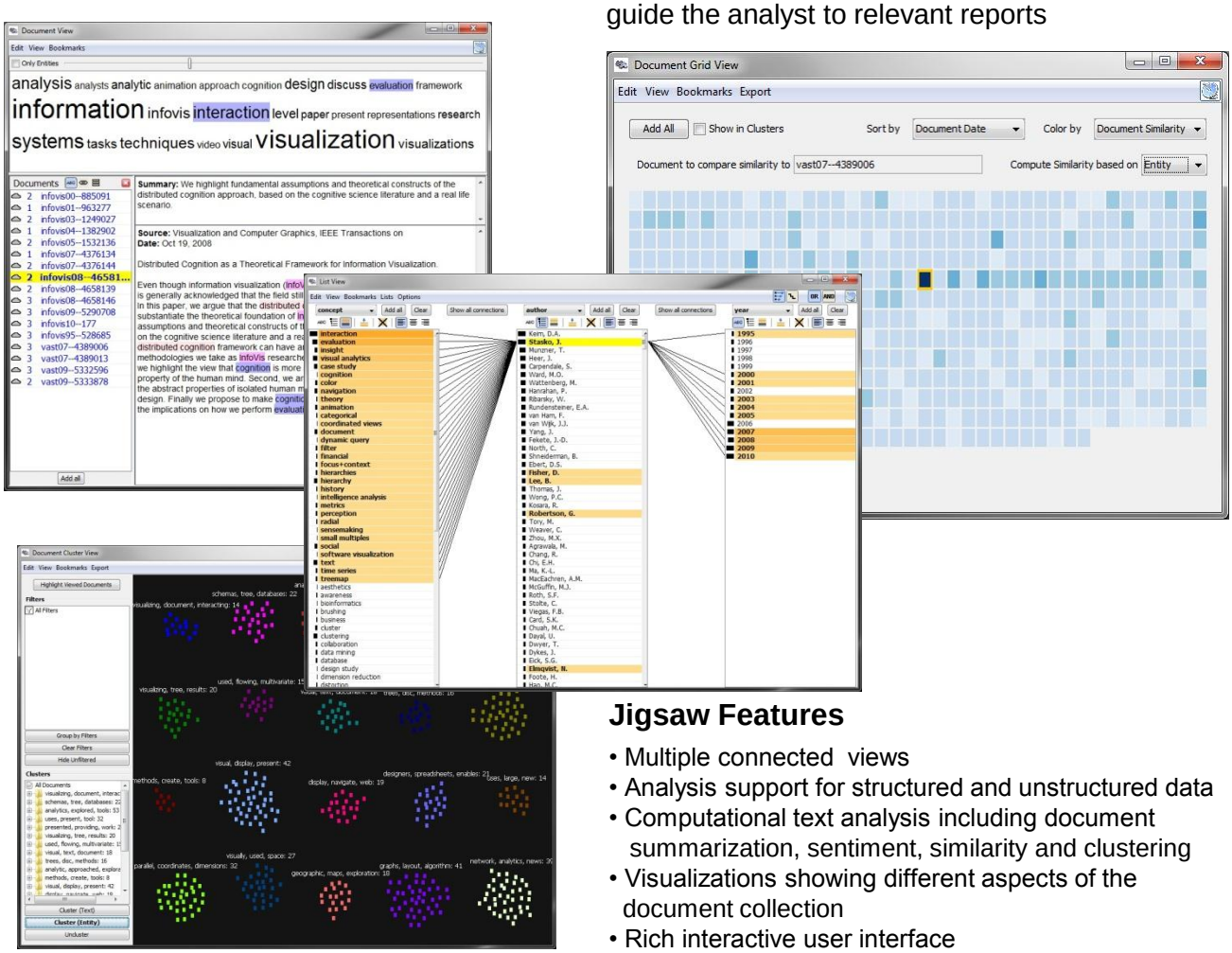
VAST 2007 Contest Winner Academic Division

Goals

- Help investigative analysts explore, analyze, and make sense of unstructured and structured document collections
- Support the discovery of hidden and embedded relationships across the documents

Approach

- Identify entities such as people, organizations, and places within a large document collection
- Highlight connections between entities
- Provide a "visual index" on those entities to guide the analyst to relevant reports



Jigsaw Features

- Multiple connected views
- Analysis support for structured and unstructured data
- Computational text analysis including document summarization, sentiment, similarity and clustering
- Visualizations showing different aspects of the document collection
- Rich interactive user interface

Download Jigsaw from: `http://jigsaw.gatech.edu`

Documentation, papers, datasets, scenario and tutorial videos can be found on the Jigsaw webpage:
http://www.cc.gatech.edu/gvu/ii/jigsaw/

For further information or questions, contact John Stasko:
stasko@cc.gatech.edu

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VALET – Visual Analytics Law Enforcement Toolkit

Benefit: *Our VALET technology provides law enforcement agencies with a suite of tools that increase situational awareness and enable the spatiotemporal exploration of multivariate data sets and police records. These tools provide advanced analytic capabilities that allow officers to develop and test hypotheses about law enforcement activities within various areas of their communities.*

Mission Need

Analyzing high volume criminal, traffic and civil (CTC) incident data is a crucial component for preventing crimes and judiciously allocating resources for the law enforcement community. However, with data sets increasing in size and complexity, and as budgets shrink and departments scale back, the ability of local law enforcement agencies to effectively analyze the data being collected becomes increasingly strained. As such, we have developed a visual analytics toolkit for enhanced exploration and analysis of multivariate spatiotemporal law enforcement data to enable advanced data exploration and analysis of CTC incidence reports. The VALET technology incorporates both intelligence led policing and community-based policing methods that enable law enforcement agencies to assess and mitigate risks due to criminal activities in their areas of responsibility.

Data Layers:
- *Criminal, Traffic, Civil*
- *Calendar Events*
- *Weather*
- *Census & Demographic*
- *GIS*
- *Moon Phase*

Collaborators:
- *Purdue University*
- *Arizona State University*
- *Purdue Police*
- *West Lafayette Police*
- *Lafayette Police*
- *Tippecanoe County Sheriff*
- *Indianapolis Police*
- *NYPD*
- *Ohio State Highway Patrol*
- *Illinois State Police*

Funded by:
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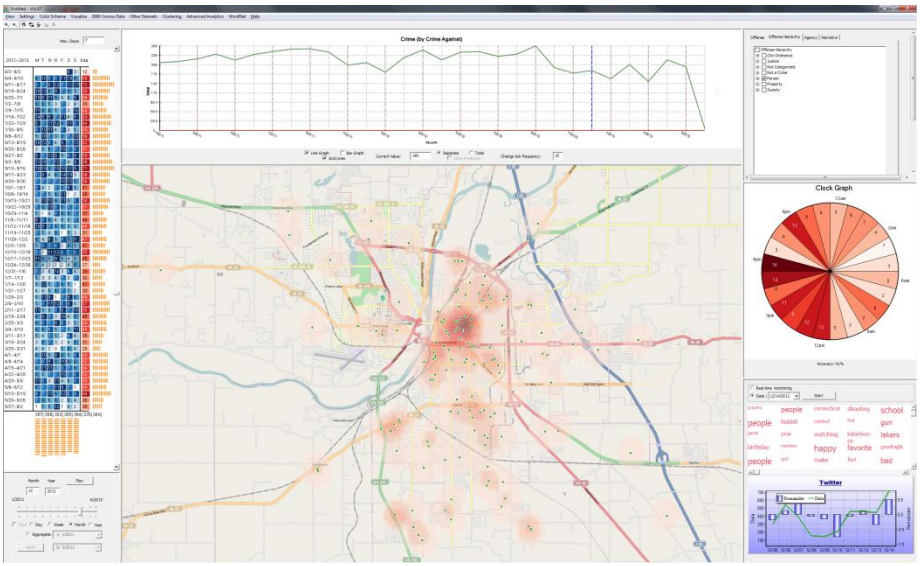

The Visual Analytics Law Enforcement Toolkit where the user is exploring crimes against person incident reports for Tippecanoe County, IN. Linked views show the line graph (top), calendar view (left) and clock view (right) temporal plots. An interactive menu showing the CTC offenses is shown on the top-right. The bottom-right view shows an interactive twitter widget that enables the detection of anomalous events. A time slider that ties all linked views together is shown on the bottom-left.

Early Development — Lab Prototype — Commercial Product

For more information, contact:
vaccine@purdue.edu
http://www.VisualAnalytics-CCI.org

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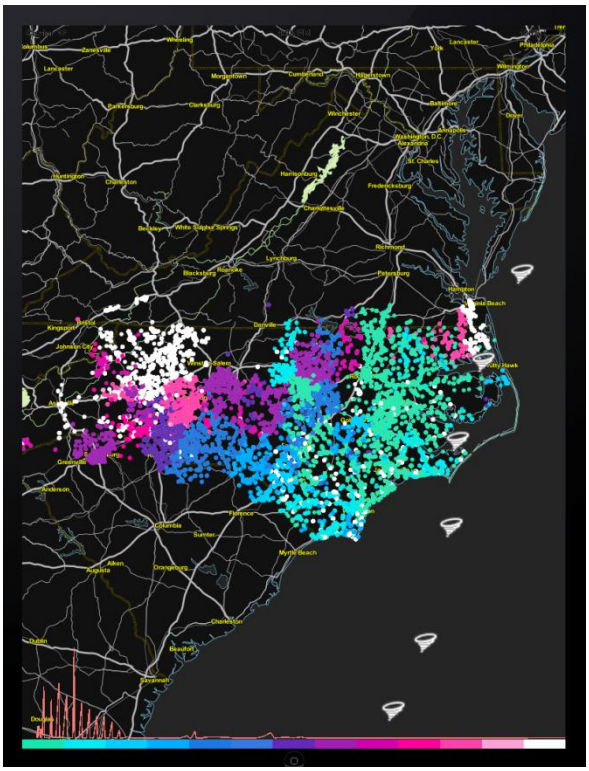
Assessing Infrastructure Resiliency during Disasters through Simulation and Visual Analysis

To reason appropriately about infrastructure behaviors and vulnerabilities in support of critical infrastructure decision-making, we have developed a critical infrastructure simulation and analysis system for situationally aware emergency response during natural disasters. Our system supports emergency planning and operation with an integrated analytical process that emphasizes a newly developed Resiliency Index (*RI*) through integrated modeling and simulating of multiple infrastructures. Such and index is situational because it will depend on the properties of the particular coupled infrastructure and will also depend on the type of occurrence that brings stress to the critical infrastructure (e.g., heat wave, hurricane, breakdown of an oil pipeline, earthquake, etc.).

As a first application, we have generated simulations based on 14 (8 historical and 6 hypothesized) hurricane paths. Currently, our simulation scope includes the infrastructures of electric power, telecommunications, water, road, and railroad transportation.

We have also developed event-based algorithms that aggregate and transform the simulation data into geospatial-temporal visualizations to enable the users to detect patterns and build new models effectively using their background knowledge and experience. A server-client architecture is in place to ensure that this analysis can be done, shared among other users, and analyzed interactively.

Our initial mobile visual analytics application is developed as an analysis portal to understand the progression of impacts on critical infrastructures. Using a mobile device, emergency responders or planners can gain an overview of critical threat situations and recovery possibilities that are derived from the massive simulation results.



Above: Overview of impacts on critical infrastructure based on 14 hurricane simulations. The timeline in the bottom indicates the significant impacts on infrastructure that typically happen towards the early stages of hurricane events. Color encodes different hurricane stages (e.g., blue-green is at an early time range in the simulation and red at a later time range).

Right: Responders can directly zoom into a certain location within a time-range to analyze in detail what is happening at that location & time.

Resiliency Indices are attached to individual commodities, and visually breakdown to main causes.

For more information, contact:
William Ribarsky ribarsky@uncc.edu and Derek Xiaoyu Wang xwang25@uncc.edu
vaccine@purdue.edu

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Coast Guard Search And Rescue Visual Analytics (cgSARVA)

Benefit: *cgSARVA is a vital component for analyzing and assessing operational efficiencies of different Coast Guard missions across the United States. The system aids with the risk assessment of potential staffing changes. The analyst will be able to understand the distribution of incidents, the risk, and the benefits involved with reallocation or reduction of resources.*

Mission Need

The Coast Guard Search and Rescue Visual Analytics (cgSARVA) is an interactive system that has been designed to assist U.S. Coast Guard decision makers and analysts in understanding and assessing the operational efficiencies of different Coast Guard missions at different organizational levels.

cgSARVA provides an interactive user interface and provides a suite of tools that enables the visualization, analysis and assessment of different Coast Guard missions. The system allows an analysis of the potential risks to the maritime environment associated with notional station closures and reallocation of different resources in terms of response time, potential lives and property lost, and provides optimal direction as to the nearest available station in case of such station closures. The system enables the analysis of trends, patterns and anomalies associated with the distribution of cases in both space and time conducted by the Coast Guard throughout the U.S.

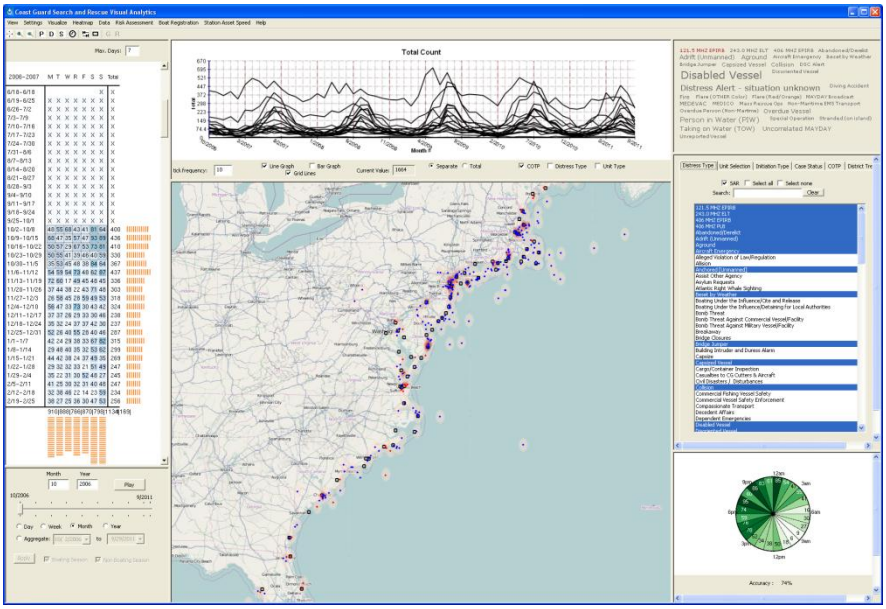
The system has been developed utilizing a user-centered approach where the expertise of several different Coast Guard analysts and decision makers has been leveraged in the design process of the system.

Collaborators:

- *United States Coastguard (U.S. Coast Guard's Fifth District, Ninth District, Headquarters and Atlantic Area Commands)*

Funded by:

- *U.S. Department of Homeland Security, Command, Control and Interoperability Center of Excellence*



Linked views for spatiotemporal analysis of U. S. Coast Guard SAR cases. The main viewing area shows the map view with the points showing the locations of SAR incidents in the east coast of the United States.

Early Development — Lab Prototype — Commercial Product

For more information, contact:
Dr. David S. Ebert, ebertd@purdue.edu
http://www.VisualAnalytics-CCI.org

Personnel:
Morteza Karimzadeh
Siddhartha Banerjee
Wenyi Huang
Yiting Ju
Frank Hardisty
Jan Oliver Wallgrün
Scott Pezanowski
Prasenjit Mitra
Alan M. MacEachren

GeoVISTA Center
The Pennsylvania State University

Benefit: *GeoTxt detects locations, people, and organizations mentioned within text and assigns geographic coordinates to those locations. This enables references to geographic locations that appear in public posts on social networks, in newspapers, and in other text sources to be harnessed for a variety of analytical tasks. GeoTxt is specialized to cope with the challenges of extracting and geolocating entities accurately from short microblog posts.*

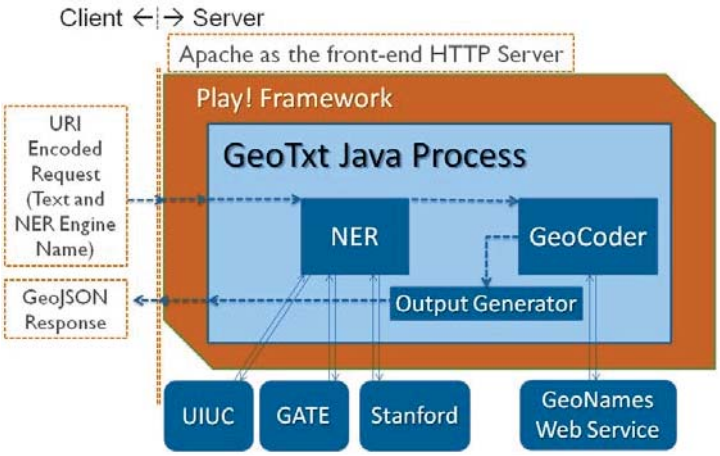
GeoTxt.org

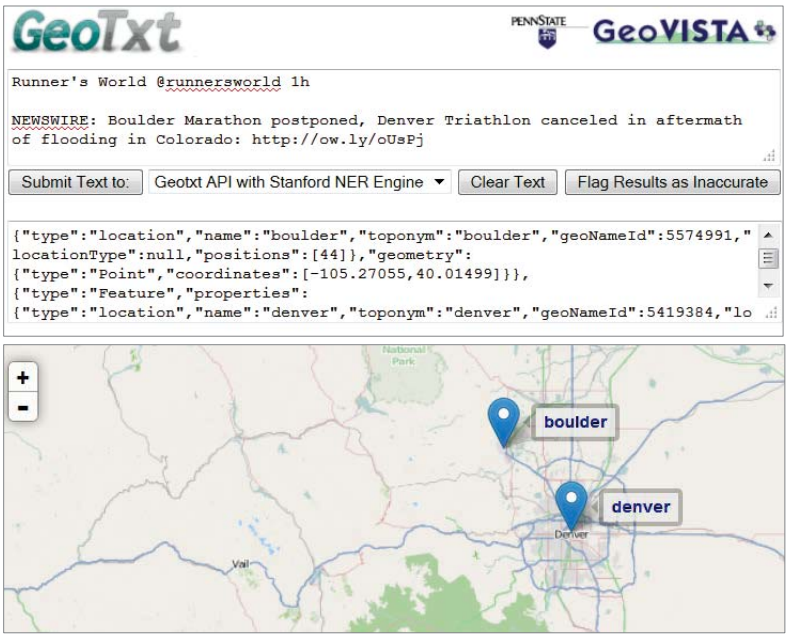
A Web Service to Geo-Locate Places in Microblog Posts and Other Textual Information Sources

In recent years, the amount of publicly available spatial data has grown tremendously, due in large part to the proliferation of GPS technologies and the location information integrated into web applications, especially social networking services. Networks like Twitter, Four-Square, and Facebook allow users to provide insights into current events in real time via short form textual updates or statuses. Many modern social networks provide a means to locate the contributor of status updates. The location of a contributor is typically given as geographic coordinates, latitude and longitude, but only a small proportion of users choose to turn "geolocation" on. With Twitter, for example, 98.5% of tweets lack explicit location information. But, there is a wealth of place-relevant information in text that is not explicitly geolocated; that information comes in the form of linguistic references to named places and place-specific features. This spatial information, along with the temporal information inherent to status updates, enables spatial and temporal analysis of contributor patterns.

GeoTxt.org is a web service that enables the geolocation of places, people, and organizations described in common status updates from online social networks, as well as from other text sources such as news stories, status reports, and blog posts. It uses techniques from a wide array of research areas – applied linguistics, natural language processing, search engine optimization, and geographic information science – to parse out places, people, and events explicitly or implicitly mentioned in text (e.g., in Twitter Tweets) and then to analyze and contextualize these entities to locate them in geographic space. The API is designed to be integrated into the development of dynamic, map-based, visual analytical interfaces, specifically in the context of crisis management and emergency response. As a proof of concept, GeoTxt now provides place recognition, disambiguation, and geolocation for SensePlace 2 (a situational awareness monitoring application developed in the GeoVISTA Center).

GeoTxt API Architecture





Figures: Diagram of the GeoTxt API architecture (left). On the right, a Tweet about current events is pasted into GeoTxt and parsed to geolocate place names mentioned (top). Those extracted locations are displayed on the map below.

Supporting Map Symbol Interoperability

Honoré Nyuyse | Honore.Nyuyse@dhs.gov
Jon Dale | jon.dale@associates.dhs.gov

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GeoVISTA

PENNSTATE 1855

DEPARTMENT OF GEOGRAPHY
COLLEGE OF EARTH AND MINERAL SCIENCES

Symbol Standards

A number of agencies within DHS employ maps as part of their daily operations. To facilitate inter-agency communication, cooperation, and consistency with map-based information and tools, DHS has directed attention to standardization of map symbology.

With the support of DHS, Penn State has been researching map symbol standardization since 2009. The goals of this research include:

1. **Investigating the use and usability of the ANSI INCITS 415-2006 standard**
2. **Developing a process to refine mission-specific symbol standards**
3. **Enabling the sharing of symbols through a feature-rich online "Store"**
4. **Determining appropriate map symbology for mobile use within DHS**

Try the Symbol Store at: http://www.symbolstore.org

We have created the Symbol Store to support map symbol interoperability. The Symbol Store allows users to search, choose, and download symbols from a **growing collection that currently exceeds 2,400 map symbols.**

Each symbol in the database is enriched with detailed metadata that includes category, agency, organization and set, rating, symbol descriptions, and user-submitted tags.

Once a search is returned users can browse through the results and can add the desired symbols to their cart. The map preview function allows users to see their chosen symbols on a variety of map types before downloading.

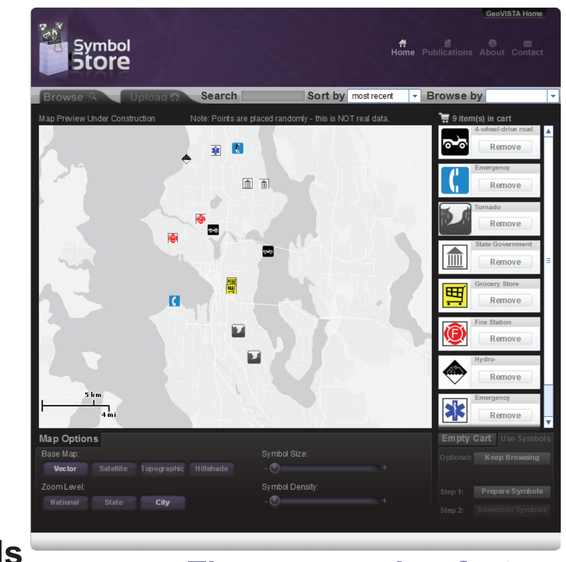
For convenient use in other mapping projects, symbols are uploaded and downloaded in the Esri Style File format. A wider variety of symbol formats, including SVG and PNG images, will be supported in one of the many updates that will be made to the Symbol Store in the near future.

The web services that make the Symbol Store possible are also open to other developers, enabling a multitude of cross-platform mapping applications.

The Symbol Store

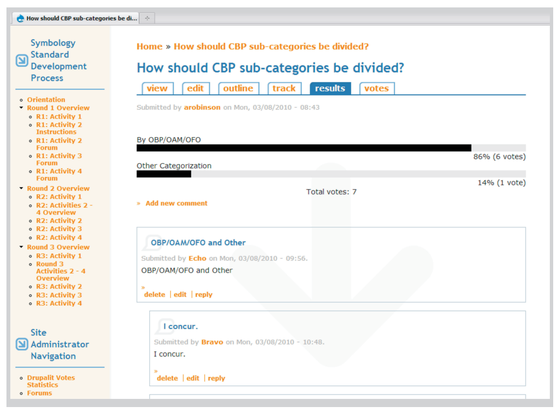
Main features include:

- **A** Keyword-based **symbol queries**.
- **B** Browse symbols by **agency**, **organization**, or **set**.
- **C** **Interactive metadata**. Clicking items generates a new search.
- **D** Users can add desired map symbols to the cart.
- **E** **Preview selected symbols on a map** before downloading.



The map preview feature includes several base maps.

e-Symbology Portal + Symbol Store



The e-Symbology Portal is a web-based environment where topics can be polled, discussed, and iteratively refined by remote participants asynchronously.

Most DHS mission areas used in-house symbol sets for internal standards. With the e-Symbology Portal, participants can collaboratively refine these standards.

Pairing this refinement process with the Symbol Store service will allow users to seamlessly organize and categorize their symbols. At this stage, users can then upload the symbols, complete with the newly added information, for others to find and use in their own projects.

Symbology for Mobile Devices

In response to the growing need for DHS missions to be carried out on cell phones, tablets, and other mobile devices, the GeoVISTA Center at Penn State is investigating design choices for mobile symbology.

The GeoVISTA Center has produced a new set of map symbols specifically designed for mobile devices.

Experiments on mobile device use and comparisons between the new mobile symbols and the existing HSWG set are currently underway.

Created 9/12/2012 by Joshua Stevens | josh.stevens@psu.edu

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VISUAL ANALYTICS DECISION SUPPORT ENVIRONMENT FOR EPIDEMIC MODELING AND RESPONSE EVALUATION

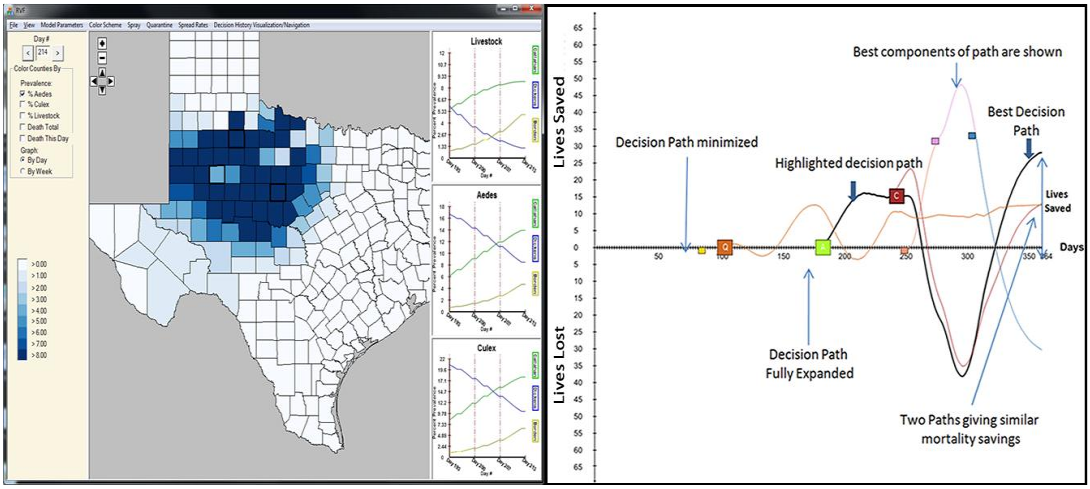
Benefit: *Interactive decision support environment in which users can explore epidemic models and their impact. This environment provides a spatiotemporal view where users can interactively utilize mitigative response measures and observe the impact of their decision over time. Our system also provides users with a linked decision history visualization and navigation tool that support the simultaneous comparison of mortality and infection rates corresponding to different response measures at different points in time.*

Mission Need

With the ever increasing threat of potential mass causality events like epidemic outbreaks (e.g. Rift Valley fever, Pandemic Influenza), public health officials must prepare, exercise and evaluate complex mitigation plans. The planning stages often rely on knowledge gained during exercises or information provided via complex modeling. Moreover, such plans are often developed with only a few specific scenarios in mind and often ignore the fact that the solutions dealing with a disease outbreak are very dependent on its underlying traits and actual characteristics, which may not be known *a priori*. Analysts need to work in an environment where they can analyze the future course of an outbreak, evaluate potential disease mitigation strategies and prepare effective mitigation plans. In order to help analysts overcome these issues, we have developed an interactive decision support environment in which analysts can explore epidemic models (e.g., Rift Valley fever, Pandemic Influenza etc.) and their impact, interactively utilize mitigative response measures and observe the impact of their decision over time under varying scenarios. In addition, analysts can also utilize doubly-linked, decision history visualization & navigation tools that can link to multiple simulation runs and provide simultaneous comparison of mortality & infection rates. Such a functionality helps analysts design an optimal mitigative response strategy under varying epidemic outbreak scenarios. Analysts will have a clear understanding of the effects that certain responses will have. In order to demonstrate our tools, we have integrated two unique epidemiological spread models. i.e. Rift valley fever and Pandemic Influenza.

Collaborators:

- *Purdue University*
- *Foreign Animal and Zoonotic Disease Defense Center*



(Left) The spatiotemporal model view. Users can watch the spread of the model over space and time and introduce changes to the simulation as well as incorporate mitigative response. (Right) The decision history tree view. As users interact in the model view, the different paths the simulation can take are calculated and visualized. The decision paths are plotted over time on the x-axis, with the y-axis representing the cumulative deviation from the baseline simulation.

Funded by:

- *US Department of Homeland Security*

Early Development **Lab Prototype** **Commercial Product**

For more information, contact:
vaccine@purdue.edu
http://www.VisualAnalytics-CCI.org

Case Study 1 – Pandemic Influenza

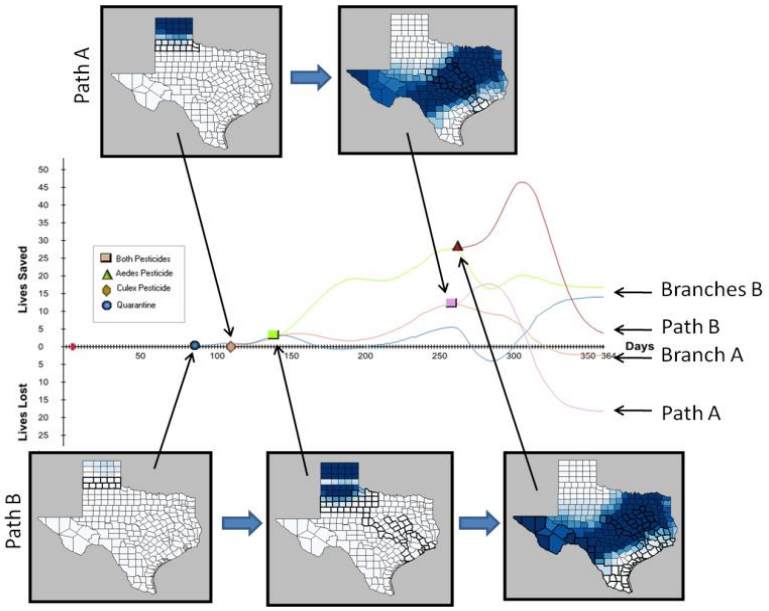
Our first epidemiological spread model utilizes a Gaussian mixture model that simulates the spread of a pandemic influenza across the united states starting from a user defined point source location and incorporating airport traffic models. Within our modeling tool, analysts can choose from three global decision measures: (1) school closures; (2) media alerts; and (3) strategic national stockpile deployment (SNS).

In this model, all decision measures are designed to mitigate the spread and each mitigative response measure can be deployed only once. Applying these decision measures in different combinatorial order can yield different mortality and infection rates. Bottom figure shows four different exploration paths, user has created. We have included a variety of decision measures along each path, including combinations of all three mitigative response. The maps surrounding the decision tree structure represent day 45 of the simulation with respect to a given decision path as indicated by the labels. Here, we can quickly see that path D1 is the optimal choice in terms of mitigating the outbreak based on the available decision metrics. The sequence of mitigative measures represented by this path saves maximum number of lives as compared to other paths.

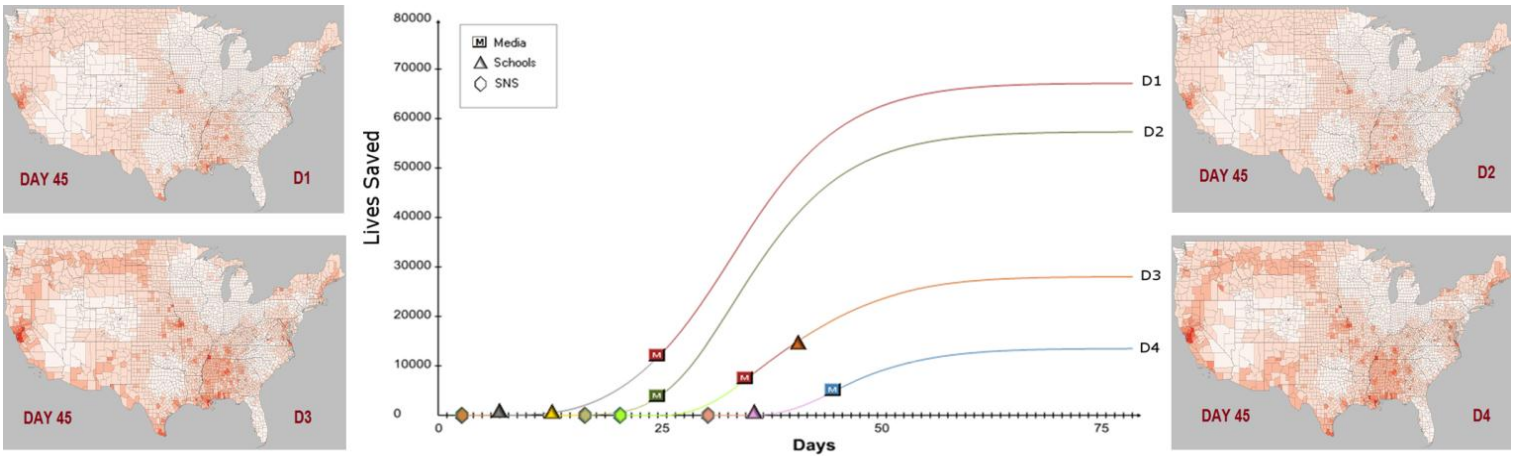
Case Study 2 – Rift Valley Fever (RVF)

Our second epidemiological spread model utilizes a differential equation model that simulates the spread of RVF through a simulated mosquito and cattle population in Texas. Users can choose from two mitigative response measures (1) pesticides; and (2) quarantine. Users are able to interactively apply a quarantine or pesticide spray to any individual county or multiple counties at once during the simulation. Analysts can combine Aedes and Culex pesticides for a combined spray.

Figure (below) shows that user has created different paths for exploration. Each path branches off from the base path whenever user performs a mitigative measure. It can be seen from the figure that path represented by green color saves maximum number of lives as compared to other paths. Path A performs worst and ends up even below the baseline simulation (which represents the absence of any mitigative measure).



Rift Valley fever Case Study. Here the user has introduced a variety of different decision measures at various points in time and in different combinatorial order. We explore the resultant simulation spaces in the geographical space with the maps surrounding the central image. Each map corresponds to a different decision tree branch as denoted by the corresponding label.



Pandemic Influenza Case Study. Here the user has introduced a variety of different decision measures at various points in time and in different combinatorial order. We explore the resultant simulation spaces in the geographical space with the maps surrounding the central image. Each map corresponds to a different decision tree branch as denoted by the corresponding label.

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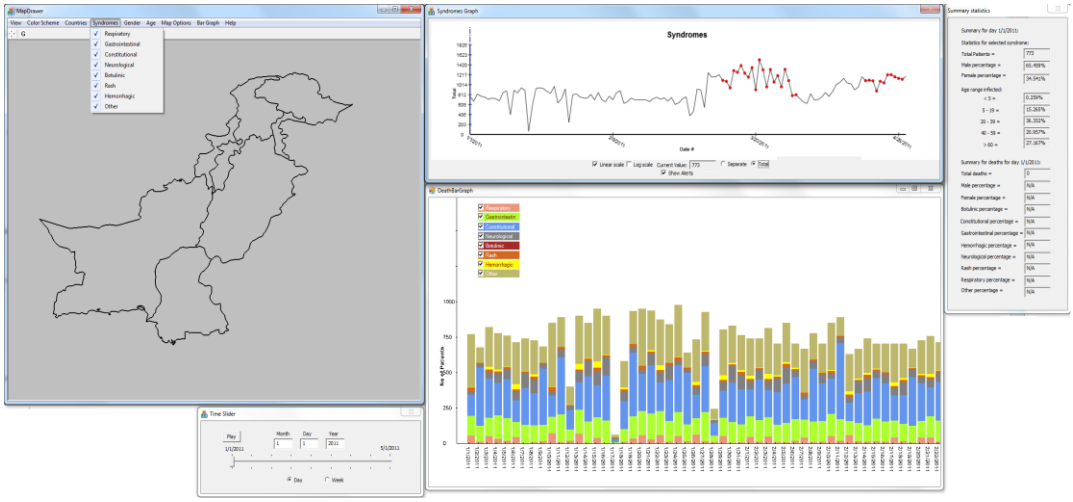
VISUAL ANALYTICS ENVIRONMENT FOR PUBLIC HEALTH SURVEILLANCE

Benefit: *A visual analytics environment for public health surveillance that can be used by health officials to identify emerging health threats in an area using chief complaints data collected by hospitals. The system can detect anomalies in temporal plots of syndromic surveillance.*

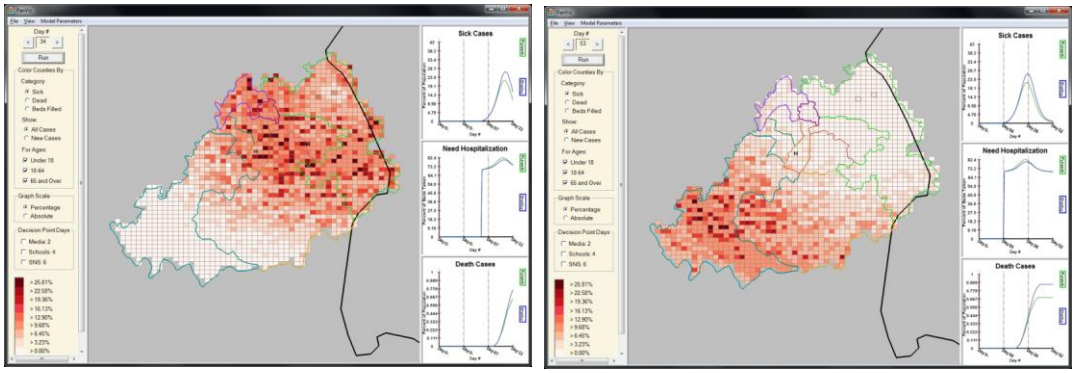
Users can also interactively explore different epidemic models and corresponding epidemic spread data in a spatiotemporal map view.

Mission Need

Assessing current and emerging public health threats is important for public health officials in order to make decisions regarding mitigative actions and allocation of resources. It also helps scientists understand the characteristics of syndromic diseases and improve their models. Patient hospital admittance records are first classified into 7 syndromes (Botulinic, Constitutional, Gastrointestinal, Hemorrhagic, Neurological, Rash, Respiratory), then the categorized data is passed to different linked components of the system. In the time series plots, EWMA control charts with a 99% confidence interval upper bound are used to identify anomalies in the data represented by red dots in the temporal plots. Hospital admittance data is also geocoded and can be used to identify any spatiotemporal patterns. Our system also allows the analyst to explore different epidemic models and visualize the spread of an epidemic in any geographical region using spatiotemporal view under certain conditions.



(Middle) Line Graph view showing health alerts for selected syndrome and region. Alerts shown fall within the 99% confidence interval for EWMA control chart. Stacked graph view shows the contribution of each type of syndrome. (Right) Summary statistics view provides details about illnesses with respect to age, gender and chief complaint. (Left) Map view. Time slider that links all the views together.



Linked Geospatial and Statistical view showing the spread of Pandemic Influenza in Lahore, Pakistan.

Early Development **Lab Prototype** **Commercial Product**

Collaborators:

- *Distributed Multimedia Systems Laboratory, Purdue University*
- *King Edwards Medical University, Lahore, Pakistan*
- *University of Engineering and Technology, Lahore, Pakistan*
- *VADER Lab, Arizona State University*

Funded by:
Defense Threat Reduction Agency
Award Number HDTRA1-10-1-0083

For more information, contact:
vaccine@purdue.edu
http://www.VisualAnalytics-CCI.org

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Visual Analytics of Microblog Data for Public Response Behavioral Analysis in Disaster Events

Benefit: *This system aids disaster management and evacuation planning. Our visual analytics system provides multiple visualizations of spatiotemporal analysis for public response behavior and increases situational awareness in disaster events using social media data.*

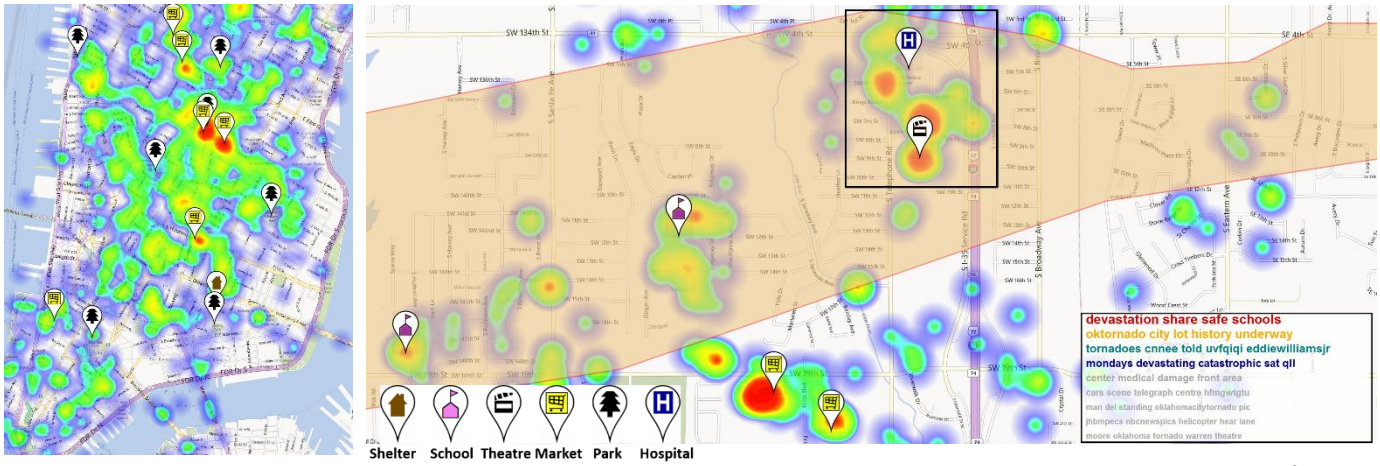
Data Layers:
Microblog Social Media
Infrastructure
Hurricane and Tornado Tracks

Collaborators:
• *Purdue University and University of Stuttgart*

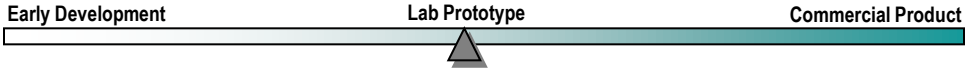
Mission Need

Analysis of public behavior plays an important role in crisis management, disaster response, and evacuation planning. Unfortunately, collecting relevant data can be costly and finding meaningful information for analysis is challenging. Location-based Social Network data, however, has substantial potential to increase situational awareness of local events and improve both planning and investigation.

To analyze such social media data, our system provides the analyst with an interactive visual spatiotemporal analysis and spatial decision support environment that assists in evacuation planning and disaster management. The system enables extraction and analysis of public response behavior from social media before, during, and after natural disasters, such as hurricanes and tornados. Analysts can examine the overall distribution of Twitter users, discover hot spots, unusual patterns, and temporal patterns of the number of Twitter users within a specific region. The analysts can utilize supplementary information (e.g., infrastructure location, Tornado path) in order to understand the events and increase situational awareness. Our system also provides analysts with abnormal topic examination within the microblog data using Latent Dirichlet Allocation (LDA) topic modeling and a Seasonal-Trend Decomposition procedure based on Loess smoothing (STL).



Spatial user-based Tweet distribution during four hours right after evacuation order for Hurricane Sandy on October 28th, 2013 (Left). A relatively large number of people immediately went to super markets nearby the evacuation area, instead of the emergency shelter. Spatial pattern of Twitter users during 24 hours in the city of Moore after damages from a strong tornado (Right). Relatively many people moved to severely damaged areas after the disaster. Topic cloud (Right-Bottom): Topics from Tweets within the selected area with a box. The topics are ordered by their abnormality scores



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vaccine@purdue.edu
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ScatterBlogs2: Real-Time Monitoring of Social Media Messages through User-Guided Filtering

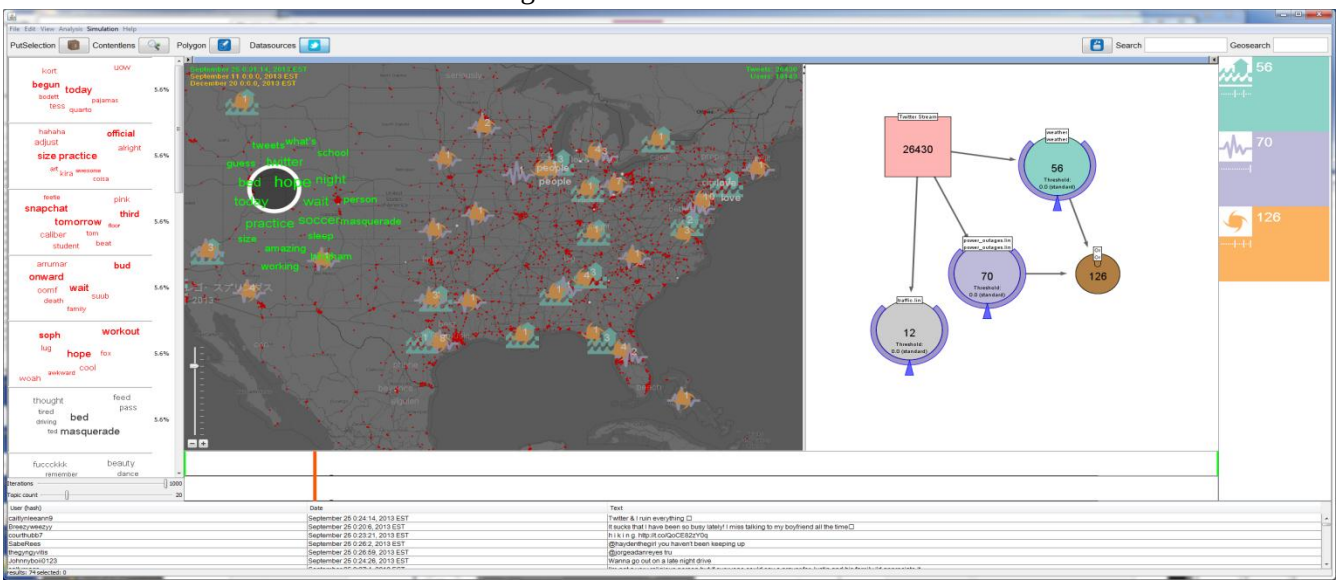
Benefit: *This technology provides analysts with scalable and interactive social media analysis and visualization through topic extraction, combination of filters, cluster examination, and stream categorization. These components are tightly integrated into a highly interactive visual analysis workbench, that allows an analyst to observe, supervise, and configure the methods in each individual analysis process.*

Collaborators:

- *University of Stuttgart*
- *Purdue University*

Mission Need

The number of microblog posts published daily has reached a level that hampers the effective retrieval of relevant messages and information, while the volume of data from services such as Twitter is still increasing. Analysts require new methods for monitoring their topics of interest, identifying trends and anomalies, and dealing with the data volume and its dynamic nature. It is of particular importance to provide situational awareness for decision making in time-critical tasks. Current tools for monitoring microblogs typically filter messages based on user-defined keyword queries and metadata restrictions. Used on their own, such methods can have drawbacks with respect to filter accuracy and adaptability to changes in trends and topic structure. We have developed a a new approach to let analysts build task-tailored message filters in an interactive and visual manner based on recorded messages of well-understood previous events. These message filters include supervised classification and query creation backed by the statistical distribution of terms and their co-occurrences. The created filter methods can be orchestrated and adapted afterwards for interactive, visual real-time monitoring and analysis of microblog feeds.



Social media analysis system including message plots on a map, a topic view, a filter view, a stream categorization view, and a table for message content. It loads traffic, severe weather, power outage classifiers, and a combination of the severe weather and the power outage classifiers on the filter view, and shows stream clusters corresponding each classifier.

Early Development — Lab Prototype — Commercial Product

For more information, contact:
vaccine@purdue.edu
http://www.VisualAnalytics-CCI.org

TRIP: Travel Response Investigative Profiler

Benefit: *TRIP is an ongoing project initiated to provide the prediction of individuals' movements through an integrated spatiotemporal visualization, exploration and analysis of multiple individuals' movement histories. Various geo-spatial and temporal cues are incorporated onto the map without using separate views. In the future, correlation analysis among individual movements and infrastructures would provide users with tools of modeling individuals' movement patterns.*

Functionality:

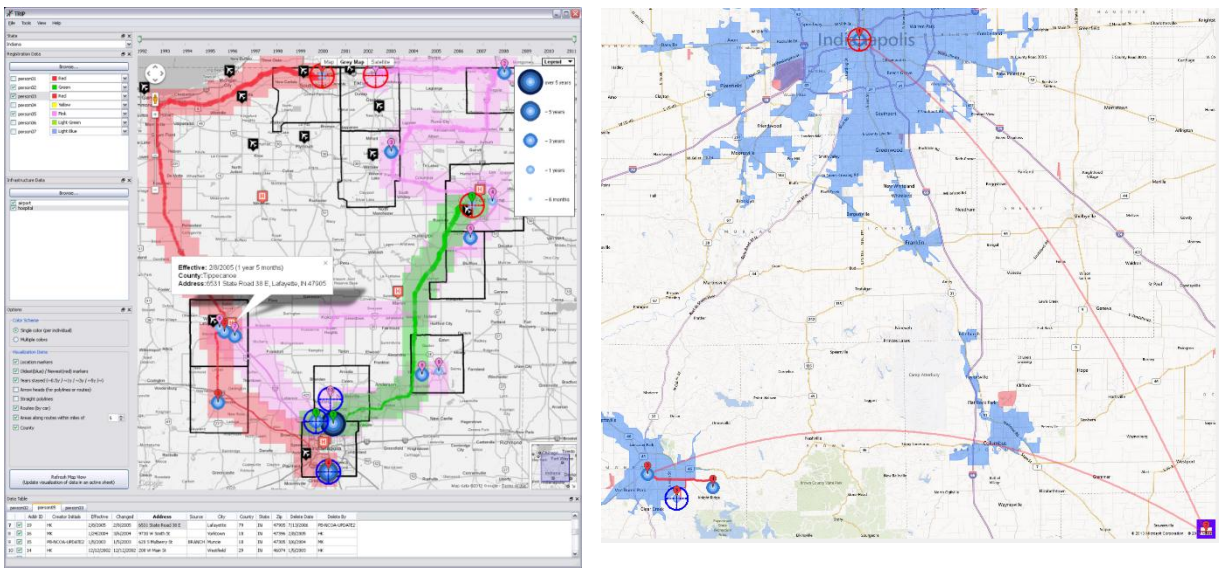
- *Geocoding through secure socket layer*
- *Driving route of movement locations*
- *Reachable areas along driving routes*
- *Various visualization items*
- *Correlation between infrastructure and individual movements*

Partners:

- *Indiana Intelligence Fusion Center*

Mission Need

As individual movements could have correlations with social and/or geo-spatial factors, it is critical to understand the spatiotemporal patterns of individual movement behavior. Given the incomplete, complex, and context dependent information, a human in their analysis and decision-making loop is crucial. Therefore, a visual analytics approach offers great potential through interactive and scalable techniques, helping analysts to extract, isolate, and examine the results interactively. TRIP allows an analyst to explore and examine spatiotemporal correlation among individual movements and between infrastructures, such as airports and schools. Given individual movement history, various spatial and temporal cues are visualized. As geo-spatial cues, location markers including newest/oldest indicators, driving routes, reachable areas along the routes and county boundaries are overlaid on the map. The routes and reachable areas are also used to present possible relationships and shared areas among individual movements and the movements and infrastructures. As temporal cues, each location is numbered in temporal order. The Route line connecting locations changes its thickness to show that an individual moved towards the direction increasing the thickness. Furthermore, the duration of stay at each location is highlighted using ring-shaped glyphs. TRIP supports various types of address data and also international addresses. The trajectories between the international and the domestic addresses are visualized with curve lines.



Multiple individuals' movement histories visualized on the map with various spatial and temporal cues (Left). Visualization of airport(red color), urban area (blue color), and an international address (Right).

Funded by:

- *US Department of Homeland Security*

Early Development — Lab Prototype — Commercial Product

For more information, contact:
vaccine@purdue.edu
http://www.VisualAnalytics-CCI.org

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Flight Delay Data Exploration System for Analyzing Spatiotemporal Multivariate Data

Benefit: *Our system provides users from government agencies (e.g., TSA, FAA) to the general public with a suite of tools that enables the spatiotemporal exploration of multivariate flight delay records. This suite of tools also enables the analysis of flight delay patterns and trends as well as provides forecasts of delays based on a given time and location using historical data.*

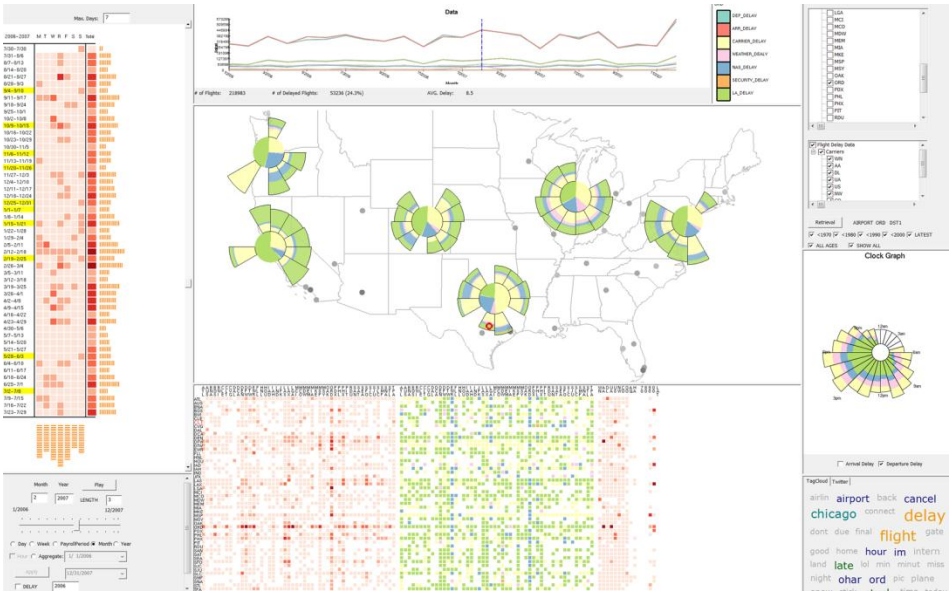
Data Layers:
- *Flight delay records*
- *TSA records*
- *Airports*

Collaborators:
- *TSA*

Funded by:
U.S. Department of Homeland Security Center of Excellence

Mission Need

Complex data with combinations of these characteristics: temporal, spatial, network-based, and multi-variate makes analysis more difficult. Example data sets showing such complexity include data from transportation, shipping, and logistics industries that have many connected operational places (e.g., origin and destination pairs) with multiple variables describing the operations in the places based on time, transactions, or incidents. In this work, we focus a visual analytics system that enables effective analysis through a suite of linked views that include networked geographical map, pixel-oriented network matrices, calendar, and clock views. In addition, we have designed new visual representations, Petal and Threads, to provide features of multiple variables among operational locations with minimized visual clutter.



Our system consists of multiple coordinated and linked views: Calendar view, Filters for selecting times (for aggregation), airports, airlines, and ages of airplanes, Line graph and correlation view, Legend view for displaying types of delays, Geographical view, Pixel view, Clock view, Twitter tag cloud view.

Early Development — Lab Prototype — Commercial Product

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vaccine@purdue.edu
http://www.VisualAnalytics-CCI.org

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Coastal Operations and Analysis Suite of Tools (COAST)

Benefit: *The visual analytics module of COAST delivers metrics based on station performance and coverage maps that allow the Coast Guard to analyze and assess operational efficiencies. The analysts use this information along with other modules of COAST to update their resource allocation plans, which can be tested and examined in the visual analytics module.*

Mission Need

The Coastal Operations and Analysis Suite of Tools (COAST) is a grand-scale effort from the Coast Guard to analyze their operations across the United States. VACCINE's current effort in the COAST project involves a visual analytic module and a resource coverage visual analytic model. In the future, the system will incorporate Boat Allocation Model data from Rutgers and support visual analysis of patrol boat routes. The system enables the analysis of case load and asset capacity per station that helps the analyst assess Coast Guard operational efficiencies based on station location and demand. The system also allows the visualization and analysis of case load and coverage for Coast Guard Air Stations.

The COAST visual analytics module aims at supporting the development of a model to determine optimal performance for both boat and air stations. The system has been developed in a user-centered approach where the expertise of several different Coast Guard analysts and decision makers has been leveraged in the design process of the system. VACCINE's COAST module was officially verified and validated for use by the US Coast Guard in April 2013 and has been used in resource planning in the wake of Hurricane Sandy.

Collaborators:

- *United States Coastguard Headquarters (CG-771)*

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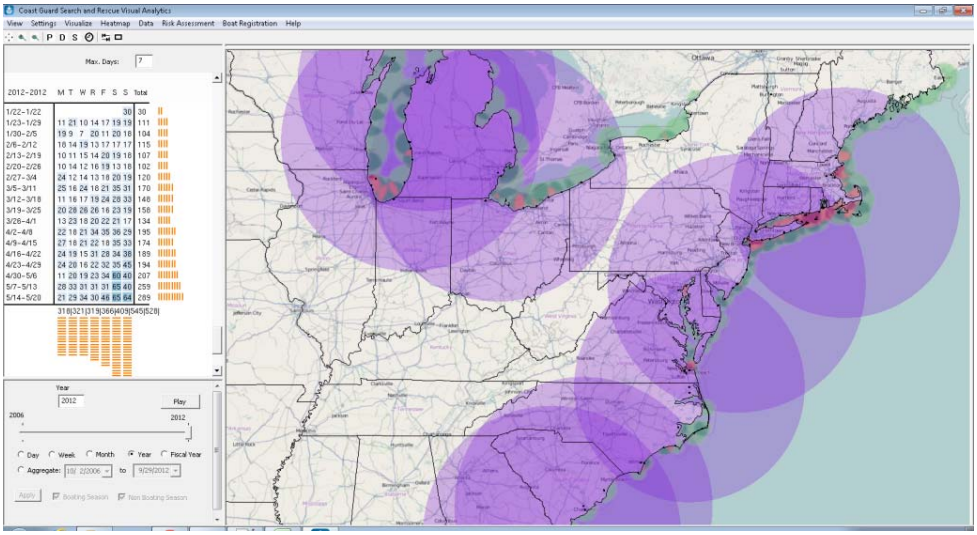


Simulated boat and air coverage showing overlaps and gaps between stations.

Early Development — Lab Prototype — Commercial Product

For more information, contact:
Dr. David S. Ebert, ebertd@purdue.edu
http://www.visualanalytics-cci.org

GARI

Gang Graffiti Automatic Recognition and Interpretation

Goal

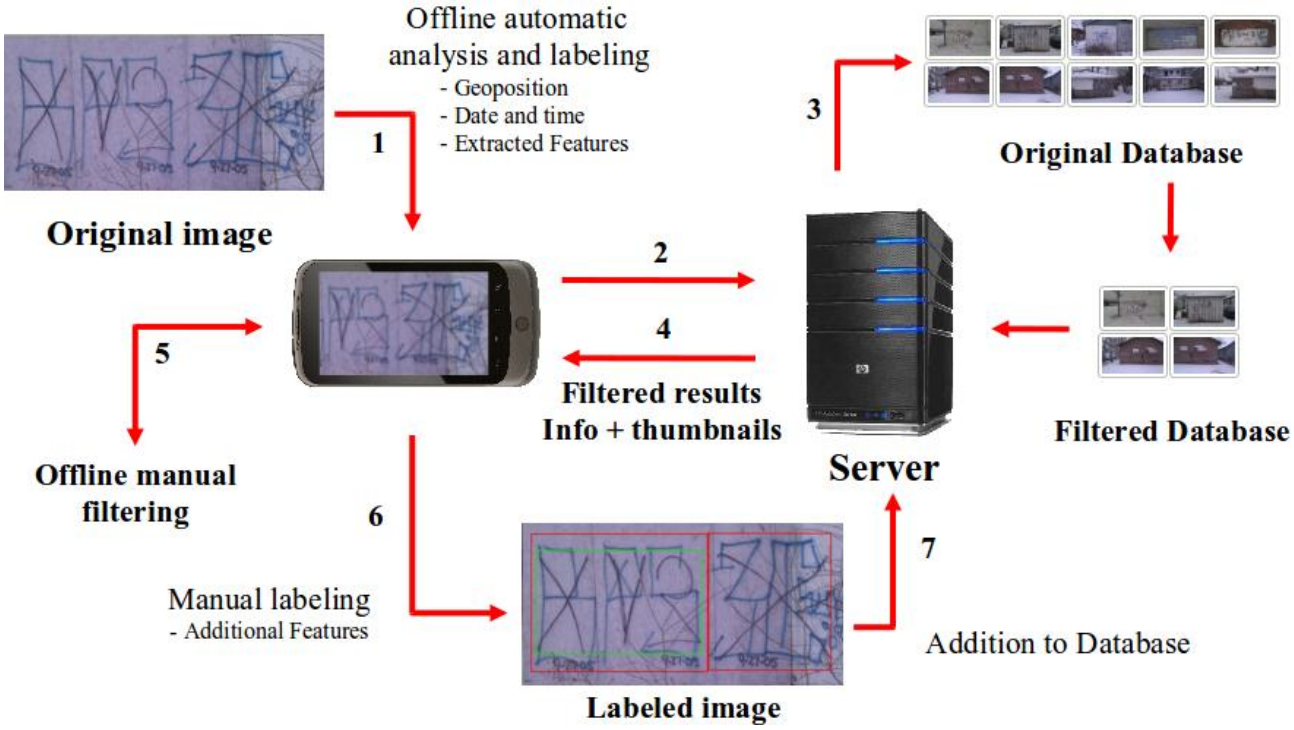
- Use image analysis techniques to identify, interpret and index gang graffiti and gang tattoo images

Approach

- Image analysis
- User friendly interface
- Database of Graffiti Images

System Overview

- Automatic analysis and tagging: metadata (geoposition, date and time)
- Bidirectional communication with server: send images, retrieve and browse database, find similar graffiti/tattoo
- User input and review
- Android/iOS Operating Systems



For more information, contact:

Professor Edward Delp
School of Electrical and Computer Engineering
Purdue University
gari@ecn.purdue.edu
Tel: 765-494-1740

www.gang-graffiti.org
13 August 2013

MERGE

Mobile Emergency Response Guide

Goal

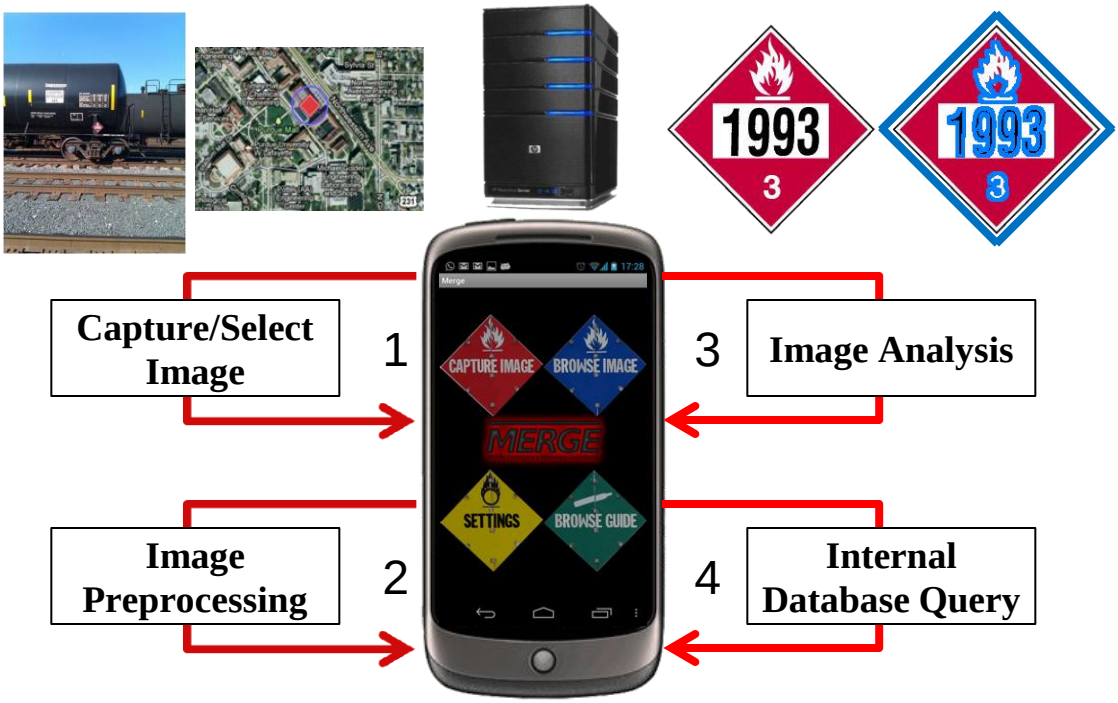
- develop a mobile-based system that uses location-based services and image analysis methods to automatically interpret the hazmat sign and quickly provide guide information to users

Approach

- Image analysis (saliency detection, object recognition) with user friendly interface
- Querying database of 2012 emergency response guidebook (ERG)

System Overview

- Capture/select image from mobile devices
- Image preprocessing on mobile devices
- Automatic image analysis
- Communication with backend server
  - send images, retrieve analysis results
- Internal database query
  - UN identifier, class, symbol, or color
- Display emergency response information
- Android/iOS mobile apps available



For more information, contact:

Professor Edward Delp
School of Electrical and Computer Engineering
Purdue University
merge@ecn.purdue.edu
Tel: 765-494-1740

www.hazmat-signs.org
13 August 2013

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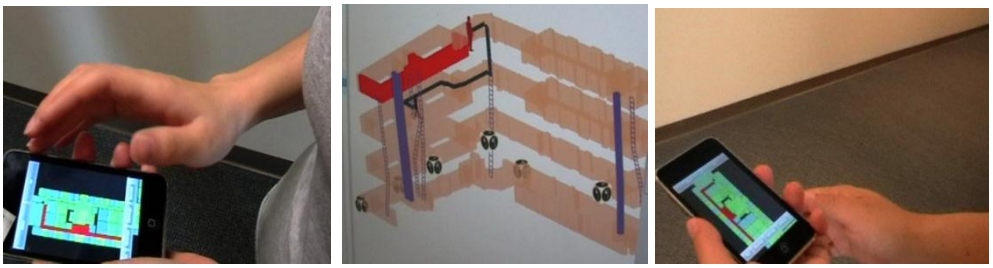
Mobile 3D Routing, Emergency Evacuation, and In-Field Criminal Investigative Analytics

Benefit: *This technology allows emergency responders to transmit or receive location information, plot 3D routes between locations, and find alternate routes if there are blocked paths. This system is designed to simulate large scale evacuations along multiple routes in a responsive and situationally aware manner.*

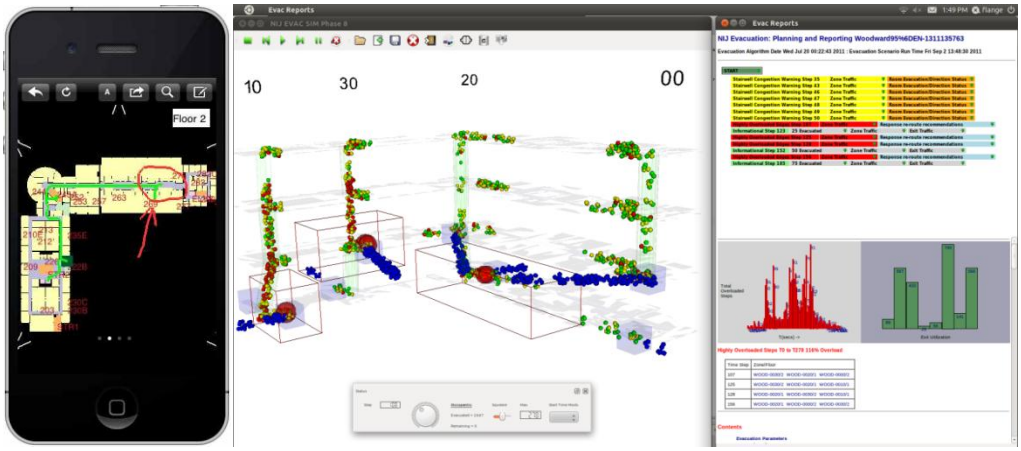
Collaborators:

- *UNC Charlotte*
- *National Institute of Justice*
- *UNC Charlotte Police*
- *UNC University System*
- *Charlotte-Mecklenburg Police Department (CMPD)*
- *DHS CAUSE-ERE*
- *NC A&T*

We have developed a mobile application for situationally aware emergency response in dense urban environments that have tall and large buildings. Using an iPhone or other mobile device, an emergency responder can transmit or receive location information, plot 3D routes between locations, and find alternate routes if there are blocked paths. All this can be done, shared among other responders, and received instantaneously. Thus the emergency responders and the command center all have situational awareness and comprehensive, personalized routing. Routing can also be extended from inside the building to the surrounding environment, enabling the system to handle larger scale evacuation along multiple routes in an efficient manner. As a first application, we have generated 3D graphs for all the academic buildings on the UNC Charlotte campus and embedded them in the street network. This environment can also be used to stand in for a dense urban neighborhood. We participated in the DHS Canada-US Experiment (CAUSE-ERE) based in Seattle for response to a Northwestern earthquake and will participate in follow-up activities. We are also working with the Charlotte-Mecklenburg Police Department (CMPD) to develop a training exercises using this environment. This exercise will permit us to test our system, our routing capabilities, and our mobile interfaces with real police officers. We will gain valuable feedback and evaluations of our system, which will be used to improve it. We have also run an on-campus shooter/emergency evacuation exercise with the UNC Charlotte Public Safety Department. The improved system will be tested with other police departments and is being deployed with UNC Charlotte Police, CMPD, and others.



From left to right: blocked hall selection and alternate route, full 3D representation of alternate route in building, receipt of blockage and routing by second user.



Left, close-up of mobile interface with search area drawn and sent to mobile user. Right, Evacuation model in left window with selected automatically generated congestion events (upper right window) indicated within boxes. New blockages can be inserted and the model updated in real time.

For more information, contact:
ribarsky@uncc.edu
vaccine@purdue.edu

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Operational Risk Assessment Module Visualization (ORAM)

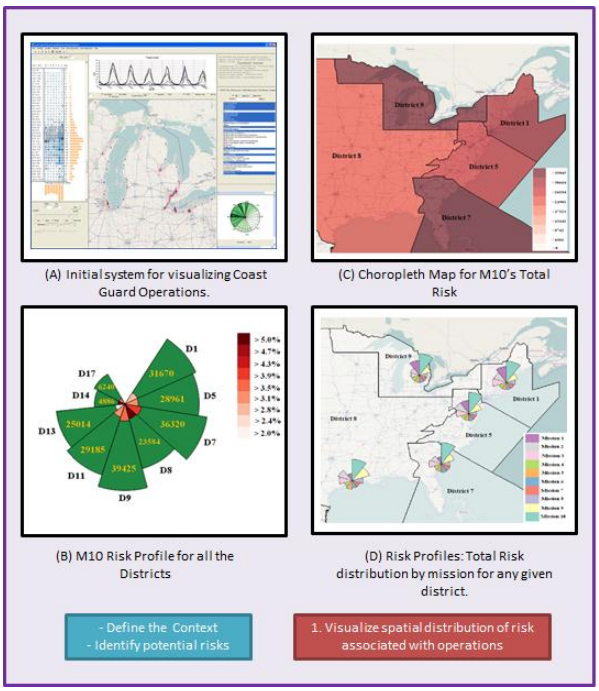
Benefit: *An interactive visual analytics system to visualize the Coast Guard operational risk assessment models and provide risk analysis that supports the distribution of resources and enables the optimization of limited assets. This tool enables decision makers to explore, analyze, drill-down, and quickly assess performance, targets, and return on investment of operations across missions and districts.*

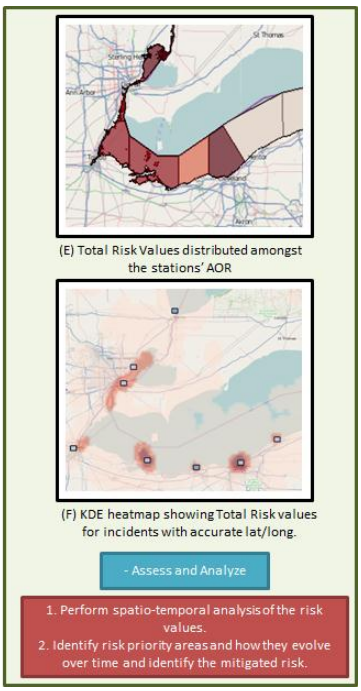
Mission Need

The Coast Guard Atlantic Area Command developed the Operational Risk Assessment Model (ORAM) to support mission planning and analysis of the 11 Coast Guard missions at the operational level. The model calculates and compares risk among Coast Guard missions and geographical areas and produces a calculated risk index number (RIN) that allows for a common measurement across different areas.

VACCINE improved the cgSARVA framework to create geographical visualizations to support the trade off decisions that the model is aimed to address. An interactive visual analytics system can help derive insights from large amounts of data and facilitate the risk management process thereby providing a suitable solution.

An interactive visual analytics system can also assist analysts and decision makers in long term planning and assessment of mitigation strategies. Our system provides multiple linked views to perform spatiotemporal analysis of risk, integrated techniques and components to visualize and identify risk priority areas, spatial distribution of RIN values, and perform coverage efficiency analysis. All of these components are integrated to provide a complete risk picture to the analyst.





Visual analytics components that support ORAM risk visualization and analysis (showing synthetic data).

Collaborators:

- *United States Coastguard Atlantic Area Command.*

Funded by:

- *U.S. Department of Homeland Security Center of Excellence*

Early Development — **Lab Prototype** — **Commercial Product**

For more information, contact:
Dr. David S. Ebert, ebertd@purdue.edu
http://www.visualanalytics-cci.org

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VASA: Visual Analytics for Security Applications

Benefit: *This system provides a visual analysis and decision making environment for severe weather and natural disaster planning and response for several critical infrastructures (e.g., power, computer networks, food distribution). Business officials and local officials can use this tool to evaluate continuity of operation plans, plan for contingencies, prepare for, and respond to a severe weather event or natural disaster. rerouting suggestions for food distribution centers impacted by a hurricane to facilitate decision-making in emergency situations.*

Data Layers:

- *Infrastructure geolocations*
- *Distribution routes*
- *Economic and business models*
- *Weather event data*

Collaborators:

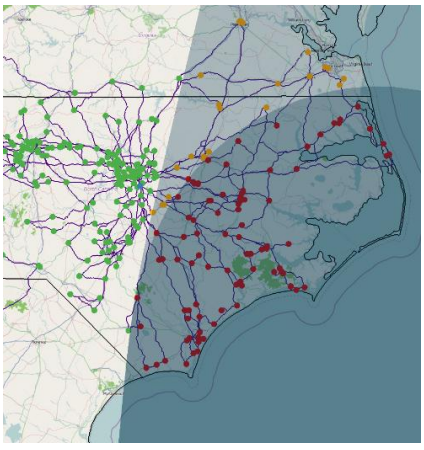
- *Purdue University (lead)*
- *Texas Advanced Computing Center*
- *University of Minnesota*
- *University of North Carolina at Charlotte*

Mission Need

Effective analysis for emergency situations caused by severe weather conditions and natural disasters requires understanding of a comprehensive set of data, including weather, critical infrastructures, and transportation network logistics. However, both civic and business analysts often encounter difficulty in estimating the impact of an event, forecasting damage, and discovering optimal solutions from various resources due to incomplete sets of data, lack of reliable simulation models, and no existing environments for decision-making. We are designing and developing a visual analytics system that provides this environment for analysts and decision-makers.

In order to provide awareness of current and forecasted impact caused by the natural events, our system presents historical and simulated events (e.g., hurricanes, tornadoes, blizzards) where users can instantly consider various scenarios, alternative and operational and simulation attributes. Based on these decisions and parameters, new simulations may be run to explore the effects on multiple critical infrastructures (e.g., power, computer networks, water, transportation, sewer) and the effectiveness of contingency plans and mitigation strategies.

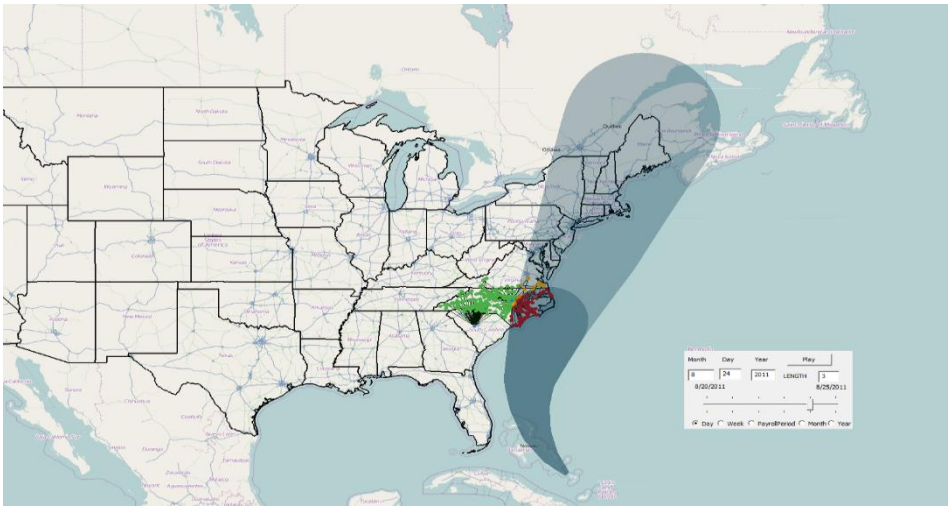
One example is a franchise food network where food delivery routes need to be changed based on store and infrastructure damage. In our visual analytics environment, analysts and decision-makers can effectively monitor the situation, understand the impact of these storms on critical infrastructure, and evaluate potential re-routed road paths for the food network with adjusted parameters.



Stores (unaffected)

Affected Stores

Impact forecasted



Hypothetical stores in North Carolina damaged by Hurricane Irene (August 2011).

Early Development — Lab Prototype — Commercial Product

For more information, contact:
vaccine@purdue.edu
http://www.VisualAnalytics-CCI.org

The Uncertainty of Identity

Benefit: *The goal of this work is to both analyze and create data that allow the creation of cybergeodemographics and their integration with geodemographic profiles of the physical embodiment of social systems. Our view is that online and conventional profiles need to be developed hand in hand, since all social interactions also take place in a physical setting, and it is simply makes no sense to consider one in isolation of the other.*

Collaborators:

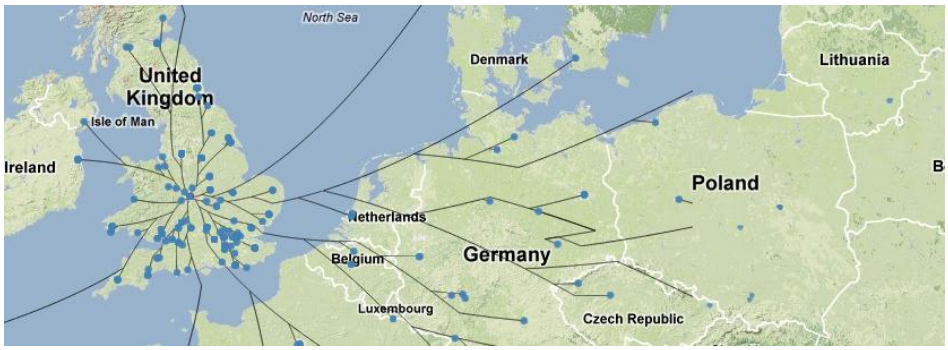
- *Purdue University*
- *University College of London*
- *Birmingham University*
- *City College of London*

Funded by:

- *US Department of Homeland Security*
- *Engineering and Physical Sciences Research Council*

Mission Need

This is an interdisciplinary project from Computer Science (St. Andrews), Engineering (City University) and Geography (UCL), in partnership with experts in Visual Analytics at Arizona State University and Purdue University in the United States. Our goal is to link information pertaining to real and virtual worlds in order to better manage the uncertainties inherent in establishing human identity. Our basic premise is that uncertainty in identifying and characterising individuals may be managed and understood by: (a) exploring and analysing spatio-temporal profiles of lifestyles and activity patterns; (b) concatenating and conflating detailed but under-exploited datasets in the virtual and real domains; and, more speculatively (c) seeking and analysing crowd sourced volunteered data that link physical and virtual identities. Through these actions it will be possible to improve our ability to characterize and validate an individual's identity, to devise improved profiles of individuals and groups that bridge the real and virtual domains, and to document and manage the uncertainties inherent in these tasks. Representative social network data are notoriously difficult to assemble, manage and analyze, and there are important ethical issues concerning their use. What we have done is begun developing incentivized social network tools to install on users' Facebook accounts and that will profile each of their contacts using statistics arising from their names and geographic residence. The innovation here is that the application will harvest names based indicators of ethnicity, age and socio-economic status, alongside approximate geographic coordinates of residence. In exchange for this, respondents will receive reports that characterize their own social networks (along with assurances that individual reports will not be shared with third parties and will only be used in aggregate in the research). Analyzed in conjunction with geodemographic profiling, the result may be the first representative linkage of virtual and real communities in time and (international) space.



Exploring the geodemographic profile between internet searches for surnames and their expected geographic locations.

Early Development — Lab Prototype — Commercial Product

For more information, contact:
Dr. Ross Maciejewsk: rmacieje@asu.edu
http://vader.lab.asu.edu