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Complexity, Analytics, and Homeland Security
U.S. Department of Homeland Security (Joseph Kielman)

For those of us interested or involved in the development of tools to aid information understanding, trying to address complexity makes the work difficult, demanding, and sometimes unsatisfying. Yet, that is the state in which we – as researchers and as private citizens - increasingly find ourselves. The term "complexity' can be applied to many, different aspects of homeland security. And, this article will briefly introduce the more significant ones that analytics must address or at least acknowledge, if it is to be successful.

Map of Soviet Union Administrative Divisions, 1989. From 1945, after the end of World War II (WWII), until 1991, the Soviet Union and the United States were the two world superpowers. The tensions of this period, known as the "Cold War", turned these WWII allies into nuclear-armed enemies, dominating the cultural, economic, scientific and athletic agendas of the world.

First, consider threats. Perhaps the best way I can illustrate my opening assertion is with some examples from recent memory. The world started becoming more complex some 25 years ago – at least for the FBI, where I was working at the time - with two signal events. These were the collapse of the Soviet Union and the demise of organized crime. In the space of one or two years at most, the two singular foci of that agency's foreign counterintelligence and criminal investigative activity were replaced, respectively, by multiple, independent foreign governments and gang-led or state-sponsored crime. Our view of the world and its adversaries just wasn't that simple anymore.

Counter-drug work, which grew in the 90s to encompass both investigative and intelligence activities, blurred those foci even more. Finally, or so it seemed, the complexity only seemed to become real some 8 years ago with the September 11th attacks. Terrorism was now a major problem and issue, encompassing right-wing or other

On September 11, 2001, al-Qaeda orchestrated a series of suicide attacks on the World Trade Center (WTC) Building in New York City (pictured above), and the Pentagon in Washington, DC.

Complexity and Analytics (cont. from front page)

U.S. Department of Homeland Security

Shown here is the flooded northwest of New Orleans and Metairie, Louisiana, after Hurricane Katrina, in 2005. The hurricane caused levee breaches in New Orleans, which allowed for massive flooding, and resulted in widespread panic and several thousand deaths throughout the Gulf Coast of the US.

factions within the US, foreign radical groups, and even state-sponsored movements. Globalization may have made the world "flat" but its complex interrelationships made it extremely difficult to understand.

Now, we are faced with new complexities. More frequent natural disasters, climate change and the physical, economic, social effects it may cause, recurring pandemic threats, economic and financial instability, and resource constraints all contribute to creating a world that is poorly described by the universe of information available to circumscribe it. We are struggling to know what threats matter.

The complexity of the data or information is the next aspect to consider. On one level, it exists in multiple modes and differing types; it comes from diverse, diffuse sources; it includes multiple languages or forms. Our tools must address all of these simultaneously. On a second level, there is a complexity associated with data assurance. By this we don't just mean security (and classification) but also provenance, confidence, and trustworthiness. Finally, the third-level complexity for the data involves the viewpoint inherent to any piece of data. The context, the perspective, the culture or social dynamics it represents are important in its understanding. Willful obfuscation or duplicity must also be detected if data are to be assessed properly.

Next is the complexity inherent in the practitioners for whom we are developing our tools. In the United States alone, there are some 60-80,000 separate local, state, tribal, federal, and quasi-governmental agencies potentially engaged in homeland security efforts. Compound this with the complexity of their missions, namely, law enforcement, public, safety, public health, emergency response, among others, and how the information to which our analytics will be applied becomes uncertain. These numbers ignore the many more community and family-oriented groups potentially involved with securing our homeland and completely disregard the role individuals play in security efforts.

Now, consider the complexity introduced by the use of the information. The data are dynamic; can the information be collected, processed, analyzed, synthesized, and understood in real time? Will it be used for tactical or short-term decision-making by practitioners in the field or in command centers? What about strategic, policy-based decisions made by state, national, or international leaders? Is the major concern the lingering effects of some incident or catastrophe or a slow, gradual destruction of manifold critical infrastructures

On April 2, 2009, world leaders attended the G20 summit in London, United Kingdom, to endeavor to find a way to tackle the World's financial crisis.

on which our way of life depends? Finally, when and where does real-time decision-making defer to long-term policy choices?

So, having begun with an assertion, this article will close with one. Data and visual analytics is the only field capable of addressing the complex problem space of homeland security and the manifold concerns that space encompasses. But working in the field is not enough. Our tools must provide not only the capabilities for dealing with the complexities of the homeland security world but more importantly improve how the homeland security enterprise functions. That in itself is a complex problem.
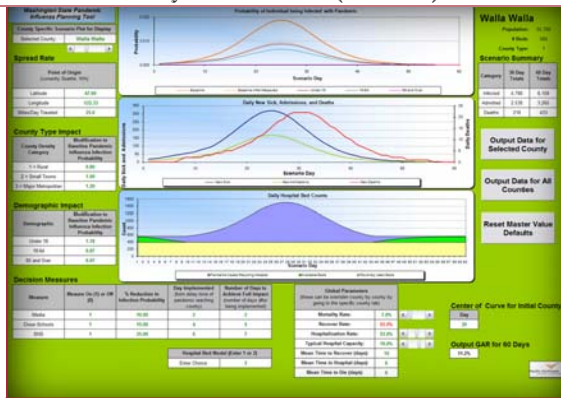
Visualization Toolkit for Analyzing/Responding to Pandemics

National Visualization and Analytics Center (NVAC)

The Pandemic Influenza Planning Tool, developed by the Pacific Northwest National Laboratory and Purdue University, was recently used during a pandemic influenza emergency exercise in Washington State.

The Pandemic Influenza Planning Tool allows health officials to carefully assess and more accurately predict how disease might evolve when various mitigation strategies are applied.

Officials simulated an H1N1 flu outbreak and used the tool to predict resource needs and shortfalls, such as the loss of key staff and a shortage of hospital beds. Visualizing possible disease progression enabled exercise participants to, for example, consider the impact of critical staff being unavailable and plan accordingly.

Researchers are improving the system's infectious disease modeling capabilities by making underlying algorithms more sophisticated and precise. Including more mitigation strategies and incorporating input from public health and emergency management experts, are priorities as developers enhance the model.

The tool has also been used for planning exercises by the Indiana State Department of Health and been was demonstrated to Washington State Public Health and emergency officials in Los Angeles County. Purdue is the lead of the recently formed Visual Analytics for Command, Control and Interoperability Environments (VACCINE) center.

VACCINE Supports the NFL

Visual Analytics for Command, Control and Interoperability Environments (VACCINE)

Members of the U.S. Department of Homeland Security's VACCINE center participated in a successful meeting with representatives from the National Football League (NFL) and local first responders at the new Giants/Jets Stadium in New York City.   Discussions focused on improving interoperability between the radio systems used by local jurisdictions surrounding the new Stadium and NFL security staff. Representatives from VACCINE's Lead University, Purdue, and the Port Authority of New York and New Jersey met with the New Jersey State Police, Bergen County Police, Ridgefield Fire Department and EMS, the NFL Stadium's security staff, the Chief Technology Officer and the Security Director from the New Meadowlands Stadium Company, and Motorola to review a software solution proposed by Motorola.

All parties agreed to move forward with this software solution, and VACCINE was invited back to evaluate the upgrades, as well as collect data for further research. The Command, Control and Interoperability Division not only manages the CCI COE but also has been working successfully with the Port Authority for more than two years on other collaborative technology implementation projects.

The new Giants/Jets Stadium is set to open April 10, 2010. It will be administered by the New Meadowlands Stadium Company, LLC.

Visual Analytics in Biology

University of Konstanz, Germany

Modern Biology, often referred to as the key science of the 21th century, is currently undergoing a transformation. The amount and complexity of the data demands the integration of traditional biology with other sciences. New theoretical concepts, modern methods of data analysis, and mathematical models will play a strategic role in molecular biology. Progress in order to reach this goals can only be achieved by intensive interdisciplinary collaboration and Visual Analytics technology will be key for success.

The recently approved research project "Finding new overlapping/embedded genes and their theory", which is part of the Priority Program

"Finding New Over-lapping/Embedded Genes and their Theory" is a collaborative initiative among scientists from the Technical University of Munich, the University of Konstanz, and the University of Ulm. This project is funded by the Deutsche Forschungsgemeinschaft (DFG), or

open reading frames, and to gain insight into the properties of overlapping genes.

Collaboration Partners of the project are information theory scientists from the University of Ulm, biologists from the Technical University of Munich, and visual analytics scientists from the University of Konstanz.

"Information and communication theory in molecular biology" (for details see http://www.uni-ulm.de/in/inkombio.html) funded by the German Science Foundation, deals with finding new overlapping genes in the quickly growing body of DNA data. Visual Analytics techniques will help to deal with the complexity of the gene analysis and clustering of the

Cyber Visualization Research Presented at FloCon

Pacific Northwest National Laboratory (PNNL)

Two visualization systems developed at PNNL through funding from DHS S&T and PNNL's Data-Intensive Computing Initiative were presented in a paper at FloCon 2010 in New Orleans, Jan 11-14. FloCon brings together analysts, developers, and researchers to discuss new technology for network flow analysis. The paper, titled "High-Throughput Real-Time Network Flow Visualization," describes the Traffic Circle and CLIQUE analysis applications and the MeDICI pipeline that connects them to live data. Traffic Circle, developed for US-CERT, depicts patterns in raw network flows using a clock-based metaphor.

CLIQUE is a modeling system for analyzing the behavior of network hosts and visually detecting anomalous departures from normal behavior. MeDICi (Middleware for Data Intensive Computing) provides the integration framework for pushing data through an analysis pipeline in real time. The PNNL tools were also presented during a FloCon demonstration session, where they attracted interest from operational customers at other government agencies. Additional customization and deployment activities are being explored with these customers.

US-Canadian Collaboration

Visual Analytics for Command, Control and Interoperability Environments

Members from VACCINE met with the President. Vice President and others of the Justice Institute of British Columbia (JIBC) Foundation in Vancouver, Canada during January, 2010, formulate a collaboration between the JIBC and VACCINE, as well as Canada and the US. In Canada, JIBC trains and educates first responders and supporting professionals, including child welfare counselors and mediators, so that they may make good decisions during critical situations. JIBC is constantly looking for new ways to attract students, and make sure those students are comfortable with technologies and research emerging in the emergency management field.

At present, the Public Safety Simulation Building and the Applied Learning Laboratory at JIBC are areas where collaborative activities can make an immediate impact. These areas represent a simulation and immersive experiential scenario environment where students practice responses and make decisions with respect to emergencies and disasters. The exercise control software for the simulation environment was developed in-house and provides a capability to monitor and record all activities, communications, decisions and rationales made by the trainee, which are reviewed in plenary sessions afterward. The data collected in such an environment could be made available to VACCINE. Also discussed was a proposal to establish a center developing, designing and running cross-border exercises using visual analytics as a framework for precision information environments.

Moving forward, VACCINE and JIBC are planning a Visual Analytics for Public Safety workshop at the JIBC, likely to be held in September, 2010. DHS will sponsor the workshop, under the terms of the US-Canadian Cooperative Activity Agreement, signed in 2007, between the two Nations.

4th Annual DHS University Network Summit

U.S. Department of Homeland Security

S&TRONG, Science and Technology for Intelligent Resilience, is the title of the 2010 University Programs Summit, to be held in March, in Washington, DC. All 13 DHS Centers of Excellence will provide speakers and subject matter experts for panels over the course of this three-day conference.

The day before the conference, March 9, is reserved for invited undergraduate and graduate students sponsored by the DHS Office of University Programs and Centers of Excellence. A poster session and a reception from 5-7pm, open to all Summit attendees, are being held in conjunction with the student day activities.
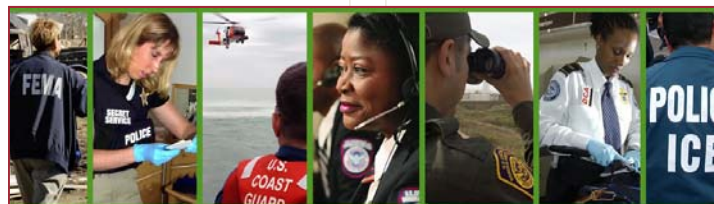
The VACCINE and CCICADA Centers will each host a 90 minute breakout panel on March 10, outlining their research activities in visual and data analytics, respectively, in support of the homeland security mission.

For more information or to register for the 2010 Summit, visit: https://www.orau.gov/dhssummit/default.htm.

Sensemaking

Command, Control, and Interoperability Center for Advanced Data Analytics (CCICADA)

The world is awash in data. People simply cannot leverage the data effectively. This problem is clearly exemplified by the terrorist attempt to destroy a Northwest Airlines flight on December 25, 2009. The United States Intelligence Community, it is now known, had information on the perpetrator, but it was lost in a sea of data. Clearly, more sophisticated analytics technologies are needed to deal with this situation. In general, today's computers do not have the capability to reach significant conclusions on their own. However, by designing assistive systems that leverage the machine's ability to discover patterns and trends using data analytics, human analysts can be freed to focus their reasoning abilities on the analytical task at hand. Such *sensemaking* systems combine visual and data analytics in a synergistic framework for problem solving and decision making. Sensemaking technologies are widely applicable to data analysis problems in virtually any domain, be it scientific, educational or business in nature.

CCICADA's design for a sensemaking framework is one instance of a more general methodology, wherein a cognitive workflow model is embodied directly in computer software. Workflow is expressed in terms of probabilistic graphical models built from actual user interaction data. CCICADA's preliminary work has defined the cognitive sensemaking models represented within a software framework, characterized the set of machine learning tasks for learning the parameters of an efficient process, and developed an initial user interface (UI) design to provide meta-cognitive UI feedback. Within this sensemaking framework, data analytics algorithms also assist a decision-maker by implicitly "connecting the dots". CCICADA partners have developed a novel approach to statistical relational learning termed "Higher Order Learning", which mimics human intuition by leveraging the latent information connecting disparate pieces of information. This approach has been demonstrated to be effective in numerous domains including e-commerce, counter-terrorism, cyber-security and defense.

Another important component of CCICADA's sensemaking research is in the enhancement of privacy. In this area, they have developed methods for enhancing privacy between multiple parties communicating sensitive information, in a distributed analytics environment. Through the study of such methods, CCICADA partners are helping establish the theoretical foundations of privacy.

These technologies are being commercialized, and associated components have been adopted by the Port Authority of New York and New Jersey Police Department, and the New Jersey State Police. Successful field tests by the U.S. Air Force have also been completed.

The Visual Analytics Digital Library

Foundations of Data and Visual Analytics (FODAVA)

This library and web portal, hosted by Georgia Tech, contains materials useful for Visual Analytics (higher) education. Georgia Tech, lead for the FODAVA project (a joint U.S. Department of Homeland Security and National Science Foundation initiative), has attempted to capture the evolving field of Visual Analytics through a prototype taxonomy, into which they have organized the library contents. The VADL includes videos, PowerPoint and recorded lectures, sample tests and exams and other documents useful to educators and students in the field. For more information and to access this resource, visit: http://vadl.cc.gatech.edu/.
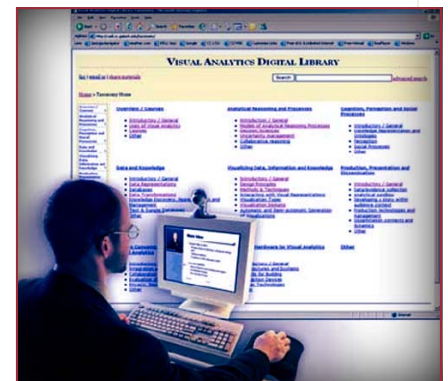
Demos of FADE and Technology Desk

Pacific Northwest National Laboratory (PNNL)

The Northwest Regional Technology Desk project embeds PNNL staff in regional law enforcement agencies to better understand their needs, help evaluate new technologies, and provide technical assistance. The project team recently has been focusing on gang issues with several interesting outcomes:

Mapping of gang graffiti. Using Google Earth, the project team developed a prototype application to map images of graffiti taken at Washington State's King County bus shelters. This prototype was enthusiastically received and is now being further developed based on client feedback.

The screen shot above is of the mapping prototype illustrating the location of images taken of graffiti. The images to the right are examples of graffiti found, photographed and mapped.

Gang database. The project team recently began developing a pilot gang database for the King County Sheriff, Seattle Police Department, and Washington State Fusion Center. This effort will allow a regionally focused gang database to be grown and shared among participating agencies. It is part of a broader pilot effort to use the FADE suite for criminal intelligence in the region. Pilot sites are scheduled to begin coming online in February .

Visual and Data Analytics at the 43rd HICSS

Command, Control and Interoperability Center of Excellence (VACCINE & CCICADA)

The Hawaii International Conference on System Sciences (HICSS) is one of the world's longest-standing continuously running scientific conferences. HICSS brings together researchers from all over the world to exchange scientific ideas, present papers, and participate in panels, all of which are designed to encourage future research. HICSS papers are then published by the IEEE Computer Society Press. Minitracks and tutorials are also offered at the HICSS conferences.

The 2010 HICSS conference, held January 5-8, 2010, included a minitrack on "Visual Analytics in the Context of the Organization", chaired by Brian Fisher of Simon Fraser University. This minitrack was merged with the Digital Media at Scale minitrack, co-chaired by Mark Elmore of Oak Ridge National Laboratory and Paul Kantor of Rutgers University. Paul Kantor is a member of the CCICADA center, and Brian Fisher is a member of its partner center, VACCINE. This minitrack is expected to repeat next year.

For the 2011 conference, VACCINE and CCICADA partners are discussing the possibility of a visual analytics tutorial, as well as the minitrack. For more information on the 2010 HICSS, visit: http://www.hicss.hawaii.edu/.

iVAC Newsletter

Integrated Visualization and Analytics Community
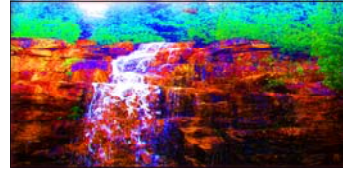
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Schedule of Events

- **TCIP 2010**
  Philadelphia, PA, USA
  February 2-4, 2010
- **Submission Deadline for EuroVAST**
  February 15, 2010
- **IEEE Pacific Visualization**
  Taipei, Taiwan
  March 2-5, 2010
- **S&T University Programs University Summit**
  Washington, DC
  March 9, 2010 (student day)
  March 10-11, 2010 (Summit)
- **GeoVA(t) Workshop**
  Guimarães, Portugal
  May 11, 2010
- **Advanced Visual Interfaces Conference (AVI2010)**
  Rome, Italy
  May 25-29, 2010
- **EuroVAST 2010**
  Bordeaux, France
  June 8, 2010
- **EuroVis 2010**
  Bordeaux, France
  June 9-11, 2010

For more information or to be added to our distribution, email: iVAC@dhs.gov