Homeland Security

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Catastrophes & Complex Systems: TRANSPORTATION

Student Day Abstract Book

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POSTERS

ORAL PRESENTATIONS

Posters

Structural and Biophysical Characterization of the Binding/Translocation Domain of *Pasteurella multocida* Toxin and Related Toxins

Michael C. Brothers[∏]*, Dr. Ram Mahajran[‡], Mengfei Ho[‡], Chad M. Rienstra* (PI) and Brenda Wilson[‡] (PI)
Student Contact: Brother3@illinois.edu PI Contact: bawilson@life.illinois.edu
Department of Homeland Security Research Fellow[∏], University of Illinois Urbana-Champaign, Department of Chemistry[*] and Department of Molecular and Cellular Biology[‡]
Research Area: Biological Threats and Countermeasures

Relevance to Listed Research Areas: *Pasteurella multocida* is a zoonotic bacterium that causes significant economic damage each year. *Pasteurella multocida* Toxin (PMT) is its primary virulence factor and is the most potent known mitogen of the biological toxins characterized. PMT is also a model toxin for an entire classification of toxins, including cytotoxic necrotizing factors and *Bordetella* dermonecrotic toxin. PMT is of particular interest as an agrosecurity threat to pets and livestock and can be transmitted to humans via respiratory exposure and animal bites. Currently there are no anti-toxins available for this class of toxins. We are studying PMT to understand the structure and function of the binding and translocation domains of PMT (N-PMT) and related toxins, all of which are potential agroterrorism/bioterrorism agents. These studies will allow us to generate novel therapeutics for PMT, including using N-PMT as a delivery vessel for anti-toxins.

Project Scope: We aim to characterize the binding partners of N-PMT on the cell surface and within the endosome in order to understand how PMT enters the cell. We are using thin-layer chromatography (TLC), surface plasmon resonance (SPR), solid-state nuclear magnetic resonance (NMR) and other methods to determine N-PMT‘s biophysical characteristics. We are also investigating the structures of the putative binding and translocation domain of PMT.

Recent Progress: Analysis of TLC data of PMT and its fragments bound to organic isolates from cell lines, including lipids, sphingolipids and ceramides, shows a preference of PMT for phosphocholine compared to ceramides, ethanolamine, and glycolipids. Thermodynamic and kinetic data from N-PMT binding to enzymatically treated HEK-293 membrane extracts was collected using SPR. Analysis supported our hypothesis that there is both a non-specific binding partner (phosphocholine) and a more specific binding partner (protein) that are important to toxin binding to the membrane extracts. To study the effects of the individual domains, we have optimized purification of the translocation domain and are in the process of generating isotopically labeled samples for structural studies using NMR.

Future Plans: Our next step is to look at the effect of removing phosphocholine and protein on binding and translocation in-vivo using flow cytometry. We will investigate the structure of the translocation domain in its solution and in its lipid bound state through NMR, providing insight into translocation of PMT. This knowledge will lead to rational design of therapeutics that use PMT as a vessel to deliver antibodies and therapeutics into cells.

Michael Brothers is a 3rd-year graduate student in the Department of Chemistry at the University of Illinois-Urbana Champaign. He is a joint student under Dr. Chad Rienstra and Dr. Brenda Wilson, where he is studying the biophysical characteristics of toxins, primarily using surface plasmon resonance and solid state nuclear magnetic resonance. His focus currently is on *Pasteurella multocida* toxin and the related dermonecrotic toxins. These toxins are primarily an agricultural threat, but because the bacterium that express these toxins are zoonotic in nature, they are a threat to the human population as well. He is also developing methods to accelerate structure generation using SSNMR data to score prospective models generated using homology-modeling programs.

Michael received his Bachelor of Science degrees in chemistry and biology in 2004 from the University of Cincinnati, graduating summa cum laude and receiving the McKibben award as the Most Outstanding Male Graduate from the McMicken College of Arts and Sciences.

Previously, Michael has worked for Sandia National Laboratories under Dr. Ken Sale modeling molecular springs, for Dr. Suri Iyer at the University of Cincinnati synthesizing sugars that bind to Shiga toxin, and for Pittsburgh Plate Glass synthesizing polymers to be used to replace commercially used polymers such as bisphenol A and polyvinyl dichloride. He also continues to work with Valley Forge Composite Technologies on development and production of the next generation of airport screeners and helped design LOKI, a long-range nuclear explosion detection system.

Defending Homeland Transportation Systems through Application of Automated Linguistic Analysis to Transcripts of Emergency Calls for Deception Detection

Mary B. Burns, Kevin Moffitt, Jeffrey L. Jenkins, Jay F. Nunamaker, Jr. (PI)
mburns@cmi.arizona.edu, jnunamaker@cmi.arizona.edu
University of Arizona, BORDERS
Social and Behavioral Sciences

Project Scope/Problem Statement/Hypothesis: A quick and decisive response to bomb threats aimed at America's complex transportation systems is crucial to prevent, mitigate, respond to, and recover from terrorist strikes. Rapidly and accurately classifying a bomb threat as "real" vs. "hoax" is imperative. Due to natural "truth bias", humans, including those with special training, have disappointing results, slightly better than chance at 54%, in detecting deception (Aamodt & Custer, 2006; Bond & DePaulo, 2006). Thus, the purpose of this research is to determine if natural language processing (NLP) data mining techniques can augment human capabilities by detecting deception accurately in a real-world, relatively unrehearsed context. As a proxy for bomb threat calls, we will use publicly available emergency calls to explore the following research question: can automated linguistic analysis techniques accurately classify deceptive vs. truthful callers in transcripts of 911 homicide calls?

Discussion on Methodology: Informed by theories of deception detection, linguistics, and computer science, we applied linguistic cue analysis techniques to transcripts of the caller's portion of 911 calls. We were able to parse the data into linguistic cue categories, such as words expressing anxiety, which enabled us to develop classification models for truthful/deceptive calls.

Discussion of Data Collection Techniques: We collected and transcribed fifty audio files of 911 calls that reported homicides, equally split between truthful and deceptive callers. To establish ground truth, we corroborated subsequent arraignment, prosecution, and/or admission of guilt via news articles of the crimes.

Results/Findings to Date: Our results suggest that truthful vs. deceptive calls can be discriminated via linguistic cue features such as more negative emotion and anxiety, reference to self in the singular or plural, or suppression of verbal responses. The overall performance of the classification techniques ranged as high as 90% for the cross-validation set.

Conclusion and Future Research: Our findings provide critical knowledge about how deceivers communicate during unrehearsed verbal exchanges. While this study focused on callers who reported homicides, future studies should investigate bomb threats. In the future, an integrated system for deception detection that can be used real-time against bomb threat calls could be added to an overall strategy for safeguarding complex transportation systems.

Mary B. Burns is a third-year Ph.D. student in the Management Information Systems Department at the University of Arizona. She earned an MBA from Harvard Business School, an MS in information science from Harvard Graduate School of Arts and Sciences, and a BS in mathematics/computer science from the College of William and Mary. She spent over eleven years in progressively more responsible positions in management of information systems and/or control functions. Additionally, she has taught Information Systems at the college level for over twelve years. In addition to research interests in automated deception/fraud detection, Mary's research interests include IS Control/Project Control and Data Security/Privacy.

Affect Segmentation and Recognition by Fusion of Facial Features and Body Gesture

Shizhi Chen, Mentor: YingLi Tian
schen21@ccny.cuny.edu, ytian@ccny.cuny.edu
Department of Electrical Engineering, the City College of New York
DHS Summer Research Team Program for MSI
Social and Behavioral Sciences

Problem Statement: Automatic affect recognition can be applied to many real-world applications including transportation security, lie detection, video surveillance, intelligent tutoring and human-computer interaction etc. Affect recognition from facial features has been widely studied before. However, affect recognition through the body gesture has just attracted attention recently, inspired by the psychology study [1].

Discussion on Methodology: The methodology we proposed is to combine both facial features and body gesture together in affect recognition. Two simple features, i.e. motion area and neutral divergence, are used to temporally segment an expression into neutral, onset, apex and offset phases. The video frames of apex phase are then selected for the affect recognition using Histogram of Gradient (HOG) features on both face and body gesture.

Discussion on Data Collection Techniques: We conduct experiments on a bi-modal face and body benchmark database FABO [3]. There are 10 expressions in the experiments, including both basic expressions and non-basic expressions. Basic expressions are "Disgust", "Fear", "Happiness", "Surprise", "Sadness" and "Anger". Non-basic expressions are "Anxiety", "Boredom", "Puzzlement" and "Uncertainty". There is total number of 288 expression videos.

Results: Experiments shows promising results on the proposed approach. The 3-fold cross validation of temporal segmentation detection rate is 83%, which exceeds the state of the art performance [2] by almost 3%. Comparing to the state of the art performance [2] with facial features only, our HOG feature based affect recognition rate has improved by 8.4%.

Conclusion, Future Research and Reference: The preliminary experiments show promising results on the temporal segmentation of an expression and the facial feature based affect recognition. Future research will focus on body gesture feature and effective fusion framework to incorporate both facial feature and body gesture in affect recognition.

[1] N. Ambady and R. Rosenthal, "Thin slices of expressive behavior as predictors of interpersonal consequences: A meta-analysis," *Psychol. Bull.*, vol. 11, no. 2, pp. 256–274, 1992.[2] H. Guenes and M. Piccardi, "Automatic Temporal Segment Detection and Affect Recognition From Face and Body Display", IEEE Transaction on Systems, Man and Cybernetics – Part B: Cybernetics, Vol. 39, NO. 1 2009.
[3] H. Gunes and M. Piccardi, "A Bimodal Face and Body Gesture Database for Automatic Analysis of Human Nonverbal Affective Behavior", in Proc. of ICPR 2006 the 18th International Conference on Pattern Recognition, Vol. 1, pp. 1148-1153, Aug. 2006, Hong Kong.

Shizhi Chen received a B.S. degree in electrical engineering from SUNY Binghamton in 2004 and an M.S. degree in electrical engineering from UC Berkeley in 2006. He is currently working on his Ph.D. at the City College of New York CUNY. Research interests include face recognition and facial expression recognition.

Actor-Actor Partnerships in Emergency Recovery Operations: A Case-Study in Humanitarian Logistics following the 2010 Haitian Earthquake

John B. Coles and Dr. Jun Zhuang (COE PI)
The State University of New York at Buffalo
Department of Industrial and Systems Engineering
Email: jbcoles@buffalo.edu and jzhuang@buffalo.edu
National Center for Risk and Economic Analysis of Terrorism Events (CREATE)
Research Topic: Emergency Preparedness and Response

Problem Statement: One of the major hurdles in the response and recovery operations following the earthquake in Haiti was the transport of goods and personnel by air and sea into the country. The ever-increasing number of organizations involved in emergency response and recovery operations has resulted in an exponential increase in the number of potential relationships that actors (governments, businesses, organizations, etc.) can choose from to form an effective supply chain during emergency response or recovery operation. We propose to identify and analyze the problems common to actors responding to the Haitian earthquake. This project provides a comprehensive overview of the challenges faced by actors operating in Haiti in obtaining relief supplies.

Methodology: This unique environment provides an excellent opportunity to identify the challenges that face actors in forming and maintaining partnerships. A research trip was conducted as a joint effort between the University at Buffalo and Texas A&M University under an NSF RAPID grant (#1034730 and #1034740).

Data Collection: Researcher John Coles interviewed 18 actors helping in the recovery process following the Haitian earthquake. Using data collected during a four-week research trip in Haiti, we explore the effect that partnerships between actors in emergency recovery operations can have on the cost and speed of relief efforts.

Findings to Date: The earthquake in Haiti reminded the emergency response community of the vulnerability of critical infrastructure to natural disasters. Developed and developing countries have a similar vulnerability to infrastructure failure of the magnitude experienced in Haiti. However, due to the fact that most response and recovery operations were performed by actors that were unfamiliar with Haiti, cooperation and partnership between actors was essential to succeed.

Future Research: Much work has been done in the United States on the effects of actor interoperability, both organizationally and technologically. However, the emergence of new organizations and the increase in foreign disaster operations highlight the importance of having an adaptive method to identify actors in emergency situations with whom a relationship should be formed. In our work we are developing a framework to support decision makers in emergency environments in the selection and development of relationships in the wake of a disaster. Using quantitative and qualitative data gathered in the wake of the Haitian earthquake, and other major disasters, we explore this operation as a case-study in emergency logistics and operational efficacy.

John B. Coles is a Ph.D. student in industrial and systems engineering at the University at Buffalo (SUNY) in Buffalo, New York. He received a B.S. in industrial engineering from the University at Buffalo and M.E. from Texas A&M University. He is a National Science Foundation graduate fellow, and has presented papers and posters at the conference for Information and Communication Technologies and Development (ICTD), Global Information Technology Management Association (GITMA), Society for Risk Analysis (SRA), and Institute for Operations Research and the Management Sciences (INFORMS). His research interests include risk communication, emergency management, disaster relief, and modeling of dynamic environments.

Social Networking Ignites Traditional Media in a Major HADR Exercise

James W. Dovine III, Eric Frost, George Bressler, InRelief.org, Buzz Manager
jwdovine@clap.name, frost@sciences.sdsu.edu
San Diego State University and BORDERS (*aka* BSI)
Emergency Preparedness and Response

Exercise 24 (x24) was a major Humanitarian Assistance Disaster Relief (HADR) event (Sept. 24-25, 2010) that engaged 79 countries and more than 12,700 people in a simulated complex emergency of earthquakes, fires, tsunami, and disease via virtual and real collaboration mimicking a real emergency much like others that have occurred. X24 tested how well organizations can quickly and efficiently tap resources and expertise worldwide by using cloud computing, social media, and Internet collaboration tools as are dramatically being used in current disasters. The specific problem addressed was how to effectively ignite social media (Twitter, Facebook, YouTube, many others) for a disaster and disaster exercise. Basically, how can you ignite social networking to go viral to assist in HADR efforts using traditional media as the blasting cap to notify people (broad-scale broadcast) and develop the online relationships needed for social media to work (collaborators had to link and respond)?

Starting nearly from scratch as a normal disaster would, how can you notify people worldwide in a way that engages them in social networking relationships to assist in HADR events? Traditional media such as TV, Radio, and online newspapers was tested as a means to rapidly spread the word about the disaster, basically in a broadcast mode seeking assistance in a two-way, collaboration mode. Collaboration certainly occurs from existing relationships and organizations, especially those dedicated to disaster response. However, creating a ~~"d~~isaster buzz" that motivates people to initiate collaboration is also powerfully done via traditional media who broadcast out to millions to hundreds of millions of people. X24 had more than 40 traditional media stories, including groups like CNN International who broadcast information about the event and seemed to be the primary ~~"i~~gniter" that motivated people to then link via Twitter, Facebook, UStream, Skype, and other tools where they were interacting and collaborating. These tools also represented a remarkable way to gather data from the field (GeoTwitter, GeoChat, Google Latitude), especially using smart phones and sending the data back into the ~~"d~~isaster visualization hub" where the inputs could be aggregated, visualized, and used to impact situation awareness for decision support. Such media-ignited crowd-sourcing profoundly contributed to decision support and field response for near real-time inputs, visualization, and situation awareness to the command center, actual field responders (on land, in air, and on water), and to engaged global collaborators.

The next evolution of X24 is scheduled for Europe in March 2011 and will simulate events in the Adriatic that damage key resources and critical infrastructure in the Balkans.

InRelief.org./VizCenter San Diego State Univ., https://sites.google.com/a/inrelief.org/24/
Hessert, Kathleen, *Social Media Transforms Disaster Relief Efforts*, Buzz Manager, 2010

James W. Dovine III is a Master of Science candidate in San Diego State University's Homeland Security Program. An erstwhile media executive with an impressive body of work, Mr. Dovine has a strong interest in media-military relations, interagency communications, and public affairs, specifically as each impact our nation's Homeland Security and National Security apparatus. He is also a DHS Fellow having recently been awarded the distinction by the Center for Island, Maritime, and Extreme Environment Security (a DHS Center of Excellence) at the 2010 Asian-Pacific Homeland Security Summit in Honolulu, Hawaii.

Mr. Dovine is an accomplished writer, producer, director, segment producer, screenwriter, playwright, and actor. His most critically-acclaimed credit, *Unsolved Mysteries*, detailed the events and circumstances leading to the death of enigmatic hip-hop artist, Tupac Shakur. The show was a USA Today critic's corner selection for best viewing and went on to become one of the highest rated episodes the long-running series ever had. Mr. Dovine has also produced for *The NewsHour* with Jim Lehrer (now PBS *NewsHour*), as well as KCET-Los Angeles *Life & Times Tonight* and WTTW-Chicago's *Artbeat Chicago*. His feature film, *Champion* was recognized for superior production quality at the 26th Annual Chicago International Television Festival. He is also a charter member of CPB/PBS prestigious Producers Academy.

Mr. Dovine holds a B.A. in English from Loyola University of Chicago, where he also acquired fluency in the Russian language.

Land-Application of Biosolids: Concerns and Consequences When Assumptions are Not Met

Heather C. Galada, Patrick L. Gurian, Arun Kumar, Mira S. Olson, Jingjie Teng, Michael Wardell, Sara Eggers, Elizabeth Casman
Hg54@drexel.edu, Plg28@drexel.edu
Drexel University, Center for Advancing Microbial Risk Assessment
Risk, Economics, and Decision Sciences

Problem Statement. While microbial risk assessments are often performed for scenarios under normal operating conditions, little attention has been paid to the consequences of deviations from good operating procedures. Such deviations can have significant influence on various aspects of a microbial risk assessment.

Methodology. In this study, we explore plausible deviations from standard good practice assumptions, which we term "failure scenarios." Land-applied biosolids was used as a convenient and safe area to test our methodology, which might have generated sensitive information if applied in a homeland security domain. A workshop was conducted with an expert panel, consisting of federal and state biosolids regulators, academics, biosolids generators, and biosolids land appliers, to develop a list of plausible failure scenarios. This sort of expert elicitation through ranking and surveys has been performed in other industries, including nanotechnology and hazardous waste management. The generation of failure scenarios has previously been used in software development. However, the combination of these two approaches used in this study, generation of failure scenarios and their risk-relevant rating, is a novel approach to the field of risk management.

Data Collection. Professionals with extensive experience in biosolids production and application, including biosolids regulators, researchers, biosolids utility workers, and private consultants, were surveyed to characterize these scenarios along six different attributes: severity, frequency, incentive to ignore control measures, gaps in existing control processes, public concern, and overall concern.

Results. The experts rated intentional dumping (unpermitted disposal) as the most severe of the failure scenarios, lack of worker protection as the most frequent, and application of Class A biosolids that have failed to meet treatment standards as the scenario for which incentives to ignore control measures are highest. Failure of public access restrictions to application sites was the scenario for which existing controls were judged the weakest, and application too close to wells was ranked highest for public concern and of highest overall concern.

Discussion. The results highlight areas for improving management plans and reducing risks. The methods developed to identify scenarios of concern for the biosolids industry can be applied to other areas of risk identification and risk management. Through expert elicitation, the generation of failure scenarios, and ranking of these scenarios, management practices and policies can be focused on the most pressing issues.

Heather Galada is a Master of Public Health graduate student at Drexel University in Philadelphia, PA. She is a DHS-sponsored fellow working with the Center for Advancing Microbial Risk Assessment (CAMRA). She graduated in 2008 from the University of Delaware with a B.S. in environmental science. Her current research projects include microbial risk assessment, participatory approaches to water and sanitation infrastructure decisions in Haiti, and assessing training needs for first responders to a bioterrorism event. Heather hopes to pursue a career in public health risk assessment and communication upon completion of her master's program in 2011.

Millimeter Wave Standoff Radar Detection System with Motion Compensation and 3D Imaging Capabilities

Galia Ghazi, Fernando Quivira, Jose A. Martinez and Carey M. Rappaport
ghazi.g@husky.neu.edu
rappapor@ece.neu.edu, jmartine@ece.neu.edu
Northeastern University, ALERT
Explosives Detection, Mitigation and Response

In this poster we present a new motion compensation algorithm used to improve the Synthetic Aperture Radar (SAR) images generated from measured data. This SAR is part of a standoff concealed object detection system for security applications. In particular, the system attempts to distinguish threat objects, such as explosives, worn under clothing, and to do so at a safe distance.

We analyze the data measured from a mm-wave radar which works in a multiple bistatic configuration. The receiver is mechanically translated across a 1.85 m aperture, while the transmitter is fixed at the center of the aperture. Although the SAR is built with high-performance mechanical components, the receiver position must be accurate to within a fraction of a millimeter and electronic means of correcting for acceleration and wobble is necessary. The motion compensation algorithm has been applied to data collected on a real Frequency Modulated Continuous Wave (FMCW) radar system. The algorithm corrects for the relative movement existing between the target and the radar system by using a corner cube fiducial in the target region as a reference. The imaging accuracy due to compensating for receiver motion is improved by 250%, which in several cases is essential for distinguishing concealed threat from innocent cases.

This poster also presents simulated results for future mm-wave standoff radar aperture configurations which would have the potential for 3D imaging capabilities. For this purpose, the system consists of a two-dimensional aperture array of receivers. The latter configuration would be able to produce the 3D images, which ultimately improves the detection performance of potential hazards.

Galia Ghazi received her B.Sc. degree in electrical engineering from K. N. Toosi University of Technology, Tehran, Iran, in 2003. She continued her studies at the University of Tehran and received her M. Sc. in electrical engineering in 2006. She then worked as a researcher in the photonic lab in University of Tehran. She started her studies for a Ph.D. degree at Northeastern University, Boston, MA, in September 2010. Since February 2010 she has joined the Center of Excellence ALERT (Awareness and Localization of Explosives-Related Threats) at Northeastern University. Her research interests include theoretical electromagnetic and numerical modeling to find solutions for complex electromagnetic problems.

Framework and Case Study for Understanding Factors Impacting Outdoor Contaminant Entry into Commercial Buildings

Liam Hendricken, Jin Wen, Andrew Persily
lth23@drexel.edu, jw325@drexel.edu
Drexel University – CDG (MRABE)
Commerce and Infrastructure Resilience

Problem Statement: Recent research and surveys have shown the negative impacts of outdoor pollutants on indoor air quality, particularly ozone and fine particles. Building design and operation strategies can help reduce these impacts but many questions remain about the factors affecting their entry rates. The ability to accurately assess indoor exposure associated with outdoor contaminant entry is therefore important in building design standards and practice, as well as the regulation of ambient air pollutants. Additionally, building classification systems can aide decision-makers in large-scale resource allocation in pre-contamination and post-contamination scenarios.

Methodology: Simulation studies will be conducted to understand the interactions and the various factors affecting outdoor contaminant entry, including building configuration and airtightness, system design and operation, and weather conditions. These simulation methods provide the only reliable means of assessing the impacts of building factors and should be more widely applied to study ambient pollutant entry and the effectiveness of various control options.

Results and Findings to Date: Multizone airflow and contaminant transport simulations were performed for a range of building factors and their impact on contaminant entry and occupant exposure was assessed for a medium-sized office building. The results indicated that envelope leakage plays a key role in outdoor contaminant entry, except in very tight buildings, effectively reducing the benefits of air filtration in ventilation systems.

Conclusions and Future Research: Simulation studies provide insight into building factors that impact outdoor contaminant entry into commercial buildings. By understanding which of those factors is integral in outdoor contaminant entry for each specific building classification subset, control strategies for pre-contamination and post-contamination scenarios can be implemented to better reduce occupant exposure and morbidity.

Liam Hendricken is a B.S./M.S. student of Drexel University and has been awarded a DHS-CDG fellowship under the title of Microbial Risk Assessment of the Built Environment (MRABE). He has attended various CAMRA events and institutes, and is currently conducting research at the National Institute of Standards and Technology (NIST).

A Bayesian Approach to Model Calibration for Weaponized *B. anthracis* Risk Assessment

Tao Hong, Patrick L. Gurian
th339@drexel.edu, plg28@drexel.edu
Drexel University, Center for Advancing Microbial Risk Assessment (CAMRA)
Research topic: Biological Threats & Countermeasures

Project Scope: The 2001 anthrax attacks not only caused the deaths of 5 people and hundreds of millions of dollars in clean up costs, but also identified several critical knowledge gaps. Further understanding of the fate and transport for *B. anthracis* spores will contribute fruitful information to risk characterization. In this project, the Bayesian Monte Carlo (BMC) method, which calibrates multiple model inputs by comparing model predictions with measurements, issued to interpret sampling results and identify the quantity of spores aerosolized after an attack.

Discussion on Methodology and Data: In this study, a published fate and transport model of pathogens' indoor air movement was selected [1]. Uncertainty distributions for parameters from the selected model (eg., turbulence intensity, particle density, setting velocity, resuspension rate, distribution of particle size, risk of exposed people, etc.) were updated using the BMC method (the posterior distribution was assessed by Markov Chain Monte Carlo (MCMC) algorithm to improve computation efficiency) by comparing model predictions with measurements from a study of the secondary aerosolization of variable *B. anthracis* spores from one of the 2001 anthrax letter attacks [2].

Results: The results indicate that the prior discussion overestimates the total released quantity, and exposed people's risk, while underestimate resuspension rate of released particle. Also, the posterior size distributions of released pathogens indicate that more large particles were released in the 2001 attack. It is estimated about 40% of pathogens left the room in which they were released.

Conclusion, Future Research: This BMC application updated the parameter ranges in a complex indoor air fate and transport model and provided new insights on parameters values. In the future, more resources should be allocated to the design of sampling strategy, since limited data restricted the performance of Bayesian updating approach.

Selected References:

1. Hong, T., P.L. Gurian, and N.F.D. Ward, *Setting Risk-Informed Environmental Standards for Bacillus Anthracis Spores.* Risk Analysis, 2010. **30**(10): p. 1602-1622.
2. Weis, C.P., et al., *Secondary aerosolization of viable Bacillus anthracis spores in a contaminated US Senate Office.* Jama, 2002. **288**(22): p. 2853-8.

Tao Hong is a doctoral candidate of environmental engineering at Drexel University. His current research is designed to promote the understanding of a biological attack, to reduce uncertainty and variability in the risk assessment, and to provide information for decision-making steps to minimize the associated mortality and economic loss, which contains 6 parts in detail:

1. Create a risk assessment framework using surface pathogen concentrations to infer exposed people's past exposure risk as well as to predict building's future residual risk

2. Develop and propagate uncertainties of a metric for comparing and ranking the threats from both aerosol and surface release of Category A pathogens

3. Carry out a mechanistic-stochastic human exposure model illustrating the impact of human interactions with fomites

4. Design a surface sampling strategy, including sampling locations and the associated sample quantities, to characterize a biological attack including the amount of released pathogens and size fractions

5. Apply Bayesian Monte Carlo technique to calibrate a fate and transport model and provide insights on parameters with little prior information

6. Develop a Bayesian statistic powered surface remediation plan to reduce the total decontamination cost and to maintain the residual risk at an acceptable level, satisfying multiple stakeholders' interests

Protecting America's Cyber Infrastructure through Understanding How Security Controls Influence Humans' Secure Behavior

Jeffrey L. Jenkins, Alexandra Durcikova, Mary B. Burns, Jay F. Nunamaker, Jr.
jjenkins@cmi.arizona.edu , jnunamaker@cmi.arizona
University of Arizona, BORDERS
Human Factors

Project Scope/Problem Statement/Hypothesis: America's cyber infrastructure plays a critical role in the secure transportation and storage of information to prevent, mitigate, respond to, and recover from catastrophes. The weakest link in this complex system has repeatedly been shown to be the human user, who because of ignorance, negligence, or malicious intent compromises security (e.g., the WikiLeaks security breach). The purpose of this research is to examine cyber security from a human-cognition perspective. Specifically, we address the following research question: how do the following commonly used security controls influence a user's decision to adhere to security best practices: the complexity of password policies, use of SecurID tokens, use of fingerprint scanners, and security training?

Discussion on Methodology: Informed by theories of human cognition and psychology, we challenge the assumption that the aforementioned security controls will positively influence users' secure behavior as intended. Rather, we predict that these security controls will have unintended positive and negative effects, such as changing cognitive effort, beliefs of data sensitivity, beliefs of severity of sanctions, or fears of being caught. In turn, these changes will affect a user's decision to behave securely.

Discussion on Data Collection Techniques: For our data collection, we conducted a laboratory experiment with 565 participants to test the influence of password policy complexity, use of SecurID tokens, use of fingerprint scanners, and secure training. Secure behavior is defined as the degree of compliance (in %) with all aspects of a company's security policy.

Results/Findings to Date: We found that as the complexity of password policies increases, users create more easily-cracked passwords because of an increase of cognitive load. Security training improves users' secure behavior; however, this positive effect almost totally diminishes a few days after the training if reminders are not given. Use of SecurID tokens and/or fingerprint scanners not only increases the technical security of a system, but also improves other aspects of users' secure behavior such as the strength of users' passwords.

Conclusion and Future Research*:* The results of this research stress the importance of considering the effect of security controls on the human cognition. If these considerations are ignored, the security controls may be counterproductive, decrease security in America's cyber infrastructure, and thereby could inhibit America's ability to prevent, mitigate, respond to, and recover from disasters.

Jeffrey L. Jenkins is a second-year Ph.D. student at the National Center for Border Security and Immigration (BORDERS) and the Center for the Management of Information, University of Arizona. He is also a Science Foundation Arizona Fellow and a National Science Foundation Fellow. His research interests include the policy and human components of information systems security. Jeffrey‘s research also examines how embodied conversational agents and artificial intelligence can be utilized to automate processes and improve human-computer interactions. He has published in several journal and conference proceedings including the Journal for Management Information Systems, the International Conference on Information Systems, HCI Research, Journal of the Association for Information Systems, The Americas Conference on Information Systems, and the Hawaii International Conference on Information Systems. Prior to beginning his doctoral program, he worked as a program manager and software engineer in various government and private sector jobs.

Detection of Botulinum Toxin Subtypes in Food Matrices

Deepti Joshi, Dr. Srinand Sreevatsan
joshi077@umn.edu, sreev001@umn.edu
University of Minnesota, Veterinary Medicine Graduate Program
National Center for Food Protection and Defense
Biological threats and countermeasures

The organism producing the toxin *Clostridium botulinum*, is widely distributed in nature, especially in soil, hence there is a significant threat that it may be bioweaponized. The current accepted diagnostic method for detection of botulinum toxin in foods is the mouse bioassay, which is not only laborious and expensive but also lacks specificity. In vitro tests for detection of toxin serotypes in food matrices are envisaged to provide improved alternatives to animal testing and faster implementation of control programs in cases of outbreaks. The goal of this research project is to evaluate the Food Biological Agent Detection Sensor Program (FBADS) system for immuno-detection of botulinum toxin. The FBADS system being tested for its limits of detection and sensitivity is the Meso Scale Diagnostics Model PR2 1900 and its botulinum assay kit. The kit is standardized to detect up to 40pg/ml toxin in raw milk. The suitability of this kit is currently being evaluated in our lab for detecting the toxin in a wide variety of food matrices to include liquid, solid and semi-solid samples like flavored milk, juices, spinach, broccoli, meat products etc along with development of methods for toxin extraction and sample preparation. The detection and identification of the targeted antigens under realistic conditions in this assay will be compared to the diagnostic ability of standard lab-based ELISA. This assay is simple to use and requires minimal training and if can be extended to apply to a variety of food matrices can prove very effective tool in case of a contamination event.

Deepti Joshi is a veterinarian from India and is currently a Ph.D. candidate in the Veterinary Medicine Program at the University of Minnesota. His major area of research is bovine tuberculosis, and he is the research assistant on a DHS project that is studying identification of botulinum toxin in food matrices.

Using Eye-Based Psychophysiological Cues to Enhance Anomaly Detection

Brent T. Langhals, Dr. Judee. Burgoon, Dr. Jay Nunamaker
brentl@email.arizona.edu
COE PI: Dr. Jay Nunamaker, Dr. Judee Burgoon
jnunamaker@cmi.arizona.edu; jburgoon@cmi.arizona.edu
University of Arizona - National Center for Border Security and Immigration (BORDERS)
Research Area: Border Security

In 1957, Mackworth defined vigilance as ―a state of readiness to detect and respond to certain changes occurring at random time intervals in the environment". This state of readiness implies a certain sustained attention or alertness to specified stimuli (Dittmar and Warm 1993). Unfortunately, extensive studies have demonstrated that over time vigilance will decrease due to a variety of causes (Davies & Tune 1969; Singh & Molloy 1993). This study seeks to find methods for sustaining attention over time, which would be quite useful for vigilance tasks such as baggage or passenger screening.

Based on previous research, psychophysiological cues such as eye openness, gaze duration, pupil dilation, saccades, and blink rate have all been shown to be indicative of changes in vigilance over time (Pattyn, Neyt et al. 2008, Van Orden, Jung, & Makeig 2000). If monitoring these cues can identify the exact moment or moments when a person begins to experience decreased vigilance, then it may be possible to identify appropriate means for stimulating the individual back to a higher level of performance.

Within a lab setting we will simulate a long duration vigilance task to assess an individual's ability to correctly detect random errors while non-intrusively monitoring eye-based psycho-physiological cues. Our experiment will ask subjects to repetitively review simulated x-rays for 40 minutes while attempting to identify 32 randomly inserted illicit materials or ―errors". While performing the task, we will use the eye tracker to monitor the subject's eye movements to determine if their psychophysiological cues are measurable throughout the experiment.

Once the subject has completed the assigned task, we will use the success/failure data to track his or her vigilance level over time to identify the approximate moment the individual began to experience a vigilance decrement base upon a statistically significant decrease in error detection. Our belief is that a common pattern of eye-based psycho-physiological cues will emerge that are uniform amongst the majority of subjects indicating potential onset of vigilance decrement.

The final product of our research is a prototype system capable of providing real-time assessment of user's vigilance levels (based on psycho-physiological cues) and instantaneously provides feedback (such as beeping) when vigilance decrement begins to occur with the purpose of improving or maintaining error detection over long duration tasks.

Brent T. Langhals is a 3rd-year Ph.D. student at the University of Arizona working in the Center for Management of Information. Brent is an active duty U.S. Air Force LTC. His research interests include vigilance, border security, and deception detection.

Systems Thinking Approach to Small Vessel Security

Leonid Lantsman, Hardik Gajjar, Nazanin Andalibi,
Blake Cignarella, Tanaira Cullens, Tiffany Walter, Jose Mesa
leonid.lantsman@gmail.com, Dr. Michael Bruno, mbruno@stevens.edu
Stevens Institute of Technology - MIREES
Maritime and Port Security

Problem Statement: With the attack on USS Cole in 2000, small vessel security has become an anticipated part of US navy and homeland security. Small vessel is vulnerable to potential exploitation by terrorists, smugglers of weapons of mass destruction (WMDs), narcotics, aliens, and other contraband, and other criminals. Our task for this research has been to apply systems thinking to develop a small vessel security and resilience strategy for six identified threat scenarios for the Port of NY and NJ incorporating technological and organizational elements. Four of the six scenarios were taken directly from the DHS 2008 Small Vessel Security Strategy and two others were identified as possible threat scenarios. DHS scenarios are water born improvised explosive devices (WBIEDs), smuggling terrorists into the U.S., smuggling weapons into the U.S., using a small vessel as an attack platform; in-house identified scenarios are using a small vessel as an obstruction and using small vessels to gain access to larger vessels.

Methodology: As the small vessel security system is a highly complex and inter-connected network of systems, it demands a clear, simplified representation to let the stakeholders and decision-makers understand the dimensions of the problem and how a change in a subsystem might impact the system as a whole.
To address that demand, we utilized a conceptual modeling tool known as a Systemigram. The Systemigram is used to illustrate a big picture of the small vessel security system, showing its main components and their interactions while approaching the system‘s objective, which is to achieve higher levels of security and resilience. Also a live crisis simulation exercise was carried out which essentially modeled what would occur if there was a threat of a WBIED on a cruise ship in the Hudson River.

Data Collection: The aim of the research was to co-ordinate the data collected by the satellite, HF radar and acoustics and electro-optics teams and design a systems approach for the problem statement.

Findings and Conclusion: At the end of eight week of summer research institute, it was found that systems approach is required which involves all the stakeholders for maritime security. Moreover, at the end of crisis simulation exercise, it was found that detection systems can detect a suspicious vessel travelling in the harbor at which point without the proper law enforcement resources technological detection is moot. Future research should, in conjunction with detection, focus on law enforcement strategies to detect suspicious behavior and viable action plans to prevent maritime attacks.

Leonid Lantsman was born in Kiev, Ukraine, and raised in Brooklyn from the age of three. He attended Cornell University for a B.A. in political science, moved to Nigeria after college and worked as a journalist for a Nigerian news magazine. In Nigeria, he became interested in how sub-Saharan African ports can be exploited by organized criminal networks to transfer illegal goods and materials. This has become one of his primary substantive interests in his doctoral studies at John Jay College of Criminal Justice, with a focus now on U.S. port and maritime security. This past summer, he attended the CSR Summer Research Institute (SRI) where he participated as a member of the Systems Thinking student research team and collaborated on developing a systems approach to small vessel security in the Port of New York and New Jersey. Based on his research in the SRI, Leonid is currently exploring situational crime prevention frameworks and how they may be applied to ports in the United States.

Non-recursive Mathematical Implementation of the Probability Tree Diagram: Part I

Alexander Nwala
Garland, A., Applied Research in Environmental Science,
Mitchell, L. Working Together For A Safer Tomorrow
Elizabeth City State University
e-mail: acnwala@mail.ecsu.edu
National Center of Risk and Economic Analysis of Terrorism Events (CREATE)
Research Area: Advanced Data Analysis and Visualization

Project Scope: Consider a scenario where there are seven evacuation routes from a city Alpha to a city Beta, according to basic Combinatorics the total number of ways to exit Alpha are 5,040 (7-factorial). This is potentially a nightmare situation from disaster planning, because it is relatively impractical to enumerate the entire evacuation possibilities or combinations by hand or with the aid of a probability tree diagram. However, after thorough data analyses and research using Combinatorics, the first part of two sets of formulae which enumerate the permutations of a given set of size n has been determined, repetition is allowed. In other words, this research introduces a non-recursive mathematical implementation of the probability tree diagram:

The frequency, f(n) = $\begin{cases} \frac{n}{s} - 1 & ; n\%s = 0 \\ \frac{n}{s} & ; n\%s \neq 0 \end{cases}$

The first term function; $x_1(n) = A + [n - sf(n)] - 1$

The second term function; $x_2(n) = \begin{cases} A + f(n) & ; f(n) < s \\ A + [f(n)\%s] & ; f(n) \geq s \end{cases}$

The third term function; $x_3(n) = \begin{cases} A & ; f(n) < s \\ A + \left[\frac{f(n)}{s}\right] & ; f(n) \geq s \\ A + \left[\frac{f(n)}{s} - s\right]\%s & ; f(n) > s^2 \end{cases}$

Recent Progress: A computer program to demonstrate a subset of the capabilities was written and a model tested. Preliminary results indicate real time applicability and enhanced levels of predictive accuracy for use in quick time evacuations such as tsunamis or fires.

Relevance to Listed Research Areas: The use of this data analysis and visualization formula can be used to critically enumerate all possible evacuation routes. Also, it is not bounded to solving a singular challenge; the capabilities of this formula span across numerous applications such as showing all possible known targets fused from fragmented or partially complete databases. The program can also include information in any format related to enumeration of all possibilities (combinations) given a set of variables.

Future Plans: Development of a Graphical User Interface (GUI) computer program to be used by disaster transportation planners, as well as a generic program for other applications.

Alexander Nwala comes from Rivers State in Nigeria, born the last child into a family of 7. He is majoring in computer science with a minor in aviation science at Elizabeth City State University. Diligence and honesty are his core values, and he is a man of principles. He is blessed by God with a creative mind that is highly adaptable to various situations even before pre-exposure. He loves to say that he is not smart but intelligent. He is highly proficient in the programming language of Visual C++ and is an adaptive user to various computer software applications. He considers himself an athlete and enjoys swimming and playing soccer. He has a great appreciation for art and nature.

He has always had a keen interest in the technology that drives the world, and for this reason he aims to be a pioneer in computer science and artificial intelligence-robotics. This decision of his started as a seed of curiosity when he was twelve. He was the kid by the corner that was always trying to understand or explain the mechanism behind that rusty clock. He never knew the course that his path was heading, but he believed in himself. That seed did not die, but continued to grow and flourish, inspiring him six years later to become a scientist.

China's Response to the Melamine Crisis: A Case Study in Actional Legitimacy

Elizabeth L. Petrun & Timothy L. Sellnow
Elizabeth.Petrun@uky.edu, Tim.Sellnow@uky.edu
University of Kentucky, The National Center for Food Protection and Defense
Communications and Interoperability

Project Scope/Problem Statement/Hypothesis: In 2008 China experienced an infant formula contamination that would eventually grow into a global crisis. Melamine, an industrial byproduct of plastic products, was discovered in powdered and liquid milk supplies. The chemical was intentionally added to formula to save money, while ensuring the formula would still pass product testing standards. Once the contamination was discovered, the company responsible for the manufacturing of the formula and the Chinese government were charged with communicating hazards to domestic and international stakeholders. This case study explicates actional legitimacy efforts enacted by both Sanlu and the Chinese government following the onset of the crisis and seeks to answer the research question: To what extent did China's actions in response to the Sanlu melamine crisis as portrayed in U.S. television media contribute to actional legitimacy? The study's hypothesis maintained that China's government and implicated businesses would attempt legitimacy building efforts to reinstate confidence in stakeholder groups; although there was minimal evidence to elucidate what types of actions the implicated organizations would pursue.

Discussion on Methodology: Using content analysis, 425 television media segments in the U.S. were scrutinized to monitor actions taken by Sanlu and the Chinese government.

Discussion on Data Collection Techniques: Using the NCFPD's ten best practices, actions taken by both organizations were monitored in U.S. television coverage from September, 2008 through February, 2009. Quantitative and qualitative data was extracted from content analysis material for discussion and further analysis.

Results/Findings to Date: Five of NCFPD's best practices were monitored in U.S. television media. These included planning ahead for a prompt response, establishing crisis communication networks, accepting uncertainty, being open and honest, and acknowledging public concern. While China successfully enacted some legitimacy building response efforts, implicated organization's efforts fell short on U.S. stakeholder groups; confidence in China's food system plummeted soon after melamine was discovered and has yet to fully recover.

Conclusion, Future Research, and References: Successes and constraints encountered by China during the crisis are highlighted in this study; recommendations are also provided for future recalls, particularly between the U.S. and China. However, the case may also be useful for other international or cross cultural organizations seeking to gain understanding of the barriers encountered by international product recalls.

Elizabeth Petrun is a first year doctoral student studying risk and crisis and organizational communication at the University of Kentucky. Elizabeth graduated with her bachelor‘s degree in integrated strategic communication and sociology magna cum laude from UK in 2008, and again in 2010 with her master‘s degree emphasizing risk and crisis communication and health communication. Her master‘s thesis studied the Chinese government‘s response to an economic adulteration case involving infant formula in 2008. Elizabeth teaches mass media and mass communication to undergraduates and enjoys researching whenever she can. Some of the research she has been involved with has focused on response to catastrophic food recalls, the H1N1 outbreak, and risk and crisis message testing.

Familiarity Recognition in Automated Screening Environments: Utilizing Eye-Tracking Technology as an Intelligence-Gathering Tool

Jeffrey Gainer Proudfoot, Jay F. Nunamaker, Judee K. Burgoon, Elyse Golob
jpoudfoot@CMI.arizona.edu jnunamaker@CMI.arizona.edu
University of Arizona – BORDERS
Border Security

A significant portion of drug-trafficking and human-trafficking operations are orchestrated by complex criminal enterprises. When drug runners and human traffickers are arrested they are quickly replaced and the criminal activity continues. The reduction of illegal activity near the border is contingent upon the apprehension of criminal leaders managing these organizations. While leaders rarely pass through screening checkpoints, lower-level members of their criminal enterprises frequently do. If a system existed that could recognize familiarity as individuals viewed pictures of criminal leaders‘ faces while passing through border checkpoints, flagged individuals could be questioned for more information.

Eye tracking systems have been utilized for a variety of purposes, one of which is identifying familiarity based on eye gaze behavior. In a recent study, researchers successfully utilized eye tracking technology to conduct a Guilty Knowledge Test (Ryan Jr, Pavlidis, Rohrbaugh, Marchak, & Kozel, 2003) to identify familiarity based on photos of manipulated objects (Derrick, Moffit, & Nunamaker, 2010). This proposal identifies a potential application of this technology in an automated-screening paradigm where individuals would view images of peoples‘ faces.

To test the feasibility of this system, a repeated-measures design will be used. During the experiment, subjects will view a compilation of images while being monitored by an eye-tracking device. A variety of control images will be displayed. To test the orienting response, altered images (an added or removed mole, tattoo, freckle, etc.) will be displayed. Subjects familiar with the individuals in manipulated photos are likely to focus on the unfamiliar facial characteristics displayed in the photo demonstrating guilty knowledge and can thus be categorized as being familiar with that individual. At a border crossing, this technology would allow agents to identify suspects affiliated with criminal enterprises, and would provide additional intelligence regarding the leaders of these dangerous organizations.

Derrick, D. C., Moffit, K., & Nunamaker, J. F. (2010). *Eye Gaze Behavior as a Guilty Knowledge Test: Initial Exploration for Use in Automated, Kiosk-based Screening*. Paper presented at the HICSS, Hawaii.

Ryan Jr, A. H., Pavlidis, I., Rohrbaugh, J. W., Marchak, F., & Kozel, F. A. (2003). *Credibility assessments: operational issues and technology impact for law enforcement applications*, Orlando, FL, USA.

Jeffrey Proudfoot is pursuing a doctoral degree in management information systems at the University of Arizona, where he is also working as a research associate for the Center of the Management of Information (CMI) under the direction of Dr. Jay F. Nunamaker. He earned both a BSIS and MSIS at the University of Utah where he also worked as a lab instructor and lecturer in the Information Systems Department. He received an award for having the highest teacher evaluations out of all graduate instructors in the business school, and was voted by his peers as being the most-valued group member in the MSIS program. His current research is focused on the development and implementation of automated screening technologies for border security, in addition to conducting research on phishing. Prior to beginning his work at the University of Arizona, he worked professionally as a web administrator for a private company in Salt Lake City, Utah. He also runs a small technology consulting business.

A Mobile Visual Analytics System for Crime Data

Ahmad M. M. Razip, Abish Malik, Ross Maciejewski, David S. Ebert, Timothy F. Collins
mohammea@purdue.edu
PI: David S. Ebert, ebertd@purdue.edu
Purdue University, VACCINE COE
Research topic: Advanced Data Analysis and Visualization

Project Scope: The exploration of incident reports for detecting trends, discovering anomalies and evaluating resource usage is an ever-expanding issue for law enforcement agencies. As such, tools need to be developed that assist law enforcement officials in their analysis to take preventive measures and judiciously allocate available resources. We have therefore developed a comprehensive visual analytics system on a mobile device which provides police officials with the ability to analyze their data on the fly for in-field improved situational awareness.

Methodology: Our system has been built upon our existing desktop version[1] and inherits some of its features. Our system consists of an application that runs as a client on a mobile device and a server-side system that provides the client with data via a Wi-Fi or a mobile data internet connection. The application was developed on Apple's iOS platform and can run on any compatible device including the iPhone, iPod, and iPad. Our system allows users to visualize data geospatially on a map and provides filtering tools that filter incidents by their type (e.g., traffic, crime type, etc.). The incidents being visualized can additionally be filtered by time to analyze correlations, emerging trends as well as escalating situations to take better preventive measures.

Data: Our system has been developed using actual law enforcement data and is currently being evaluated and refined by a consortium of law enforcement agencies.

Results & Conclusion: Our system enables users to view a history of incidents and forecast a pattern of incidents correlating to any location and time. Users are also able to monitor criminal and traffic data simultaneously. Moreover, as the system is deployed on a mobile device, the users have the ability to receive an immediate feed of events. This is especially beneficial to first responders and allows them to better deal with any catastrophic situations and respond more effectively to the crises.

Future Work: This includes improving the application through user evaluation and creating automated tools to increase efficiency and accuracy of analyzing data.

References:

1. Abish Malik, Ross Maciejewski, Timothy F. Collins and David S. Ebert. Visual Analytics Law Enforcement Toolkit. IEEE International Conference on Technologies for Homeland Security, 2010.

Ahmad Mujahid Mohammed Razip is a senior in electrical and computer engineering at Purdue University. He worked with the VACCINE (Visual Analytics for Command, Control, and Interoperability Environments) Lab in the summer of 2010 under the Summer Undergraduate Research Fellowship (SURF) program and developed mobile applications for research purposes on the iPhone platform. He is currently working as an undergraduate research assistant in the same lab and is developing a mobile application for spatiotemporally analyzing law enforcement data. His research interests include visual analytics and mobile information visualization. He can be contacted at mohammea@purdue.edu.

Defeating Eye Tracking

Ryan Schuetzler, Jay Nunamaker
rschuetzler@cmi.arizona.edu, jnunamaker@cmi.arizona.edu
University of Arizona and BORDERS
Social and Behavioral Sciences

Problem Statement: An eye tracker has recently been shown to be an effective way of administering a Guilty Knowledge Test (GKT) [1]. However, one of the primary assumptions to this point in eye tracker research has been willing participants who are unaware of the nature of the eye tracking tests. In laboratory environments this assumption can be taken for granted. Unfortunately it will not always hold in a real-world environment. Subjects' willingness to use the eye tracker could range from willing participation to belligerence.

We propose to study the different eye gaze behavior patterns of individuals with varying intentions and levels of familiarity with an eye tracker. We hypothesize that individuals intending to deceive the eye tracking GKT will display different eye gaze behavior patterns from innocent individuals.

Methodology: We will use an experiment to compare the eye gaze patterns of innocent and guilty subjects. One control group will be given no guilty knowledge, and will pass through a GKT. There will be two experimental conditions involving guilty knowledge. One will receive just guilty knowledge, and will pass through the GKT. The second will be given guilty knowledge and training about what the eye tracker is examining.

Data Collection: Data will be collected using an EyeTech TM3 eye tracking device. This device captures fixation points, blink patterns, and pupil dilation.

Results to Date: This research is currently in the initial stages, and there are no results to report to date.

Conclusion, Future Research, and References: The primary purpose of this research is to evaluate the ability of knowledgeable subjects to subvert an eye tracking activity and appear innocent. If distinctive patterns can be discerned that are unique to guilty subjects, the validity of using an eye tracker for the guilty knowledge test will be further confirmed.

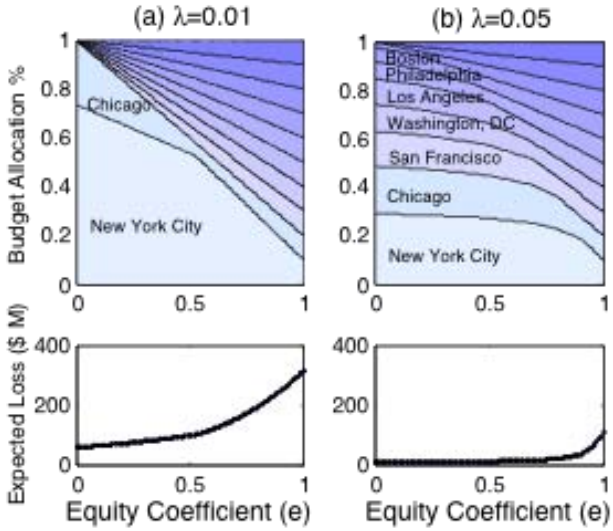
1. Derrick, D.C., et al., *Border Security Credibility Assessments via Heterogeneous Sensor Fusion.* IEEE Intelligent Systems, 2010. **25**(3): p. 41-49.

Ryan Schuetzler is a doctoral student in the Management Information Systems Department at the University of Arizona in the Eller College of Management. Ryan received his master's degree in information systems management from Brigham Young University in 2010. While there he participated in the Ph.D. preparation program directed by Dr. Paul Lowry. He currently works at the Center for the Management of Information under the direction of Dr. Jay Nunamaker.

Cost of Equity in Homeland Security Resource Allocations in the Face of Partially Strategic Attacker

Xiaojun Shan and Jun Zhuang (COE PI)
xshan@buffalo.edu and jzhuang@buffalo.edu
University at Buffalo, The State University of New York
Department of Industrial and Systems Engineering
National Center for Risk and Economic Analysis of Terrorism Events (CREATE)
Research Area: Risk, Economics, and Decision Sciences

Problem Statement: Adversary could be either adaptive and non-adaptive, suggesting a hybrid model of game theory and traditional risk analysis. On the other hand, the tradeoff between equity and efficiency is an important factor in homeland security resource allocation.



Methodology: We develop a hybrid model for identifying optimal defensive resource allocation strategies of a centralized defender while reserving a portion for equal distribution (according to geographical areas, target valuations, population, density, and density-weighted population), assuming that the adversaries might behave strategically or non-strategically. Strategic attack probabilities are endogenously determined by the model and are adaptive to the defender's decision. In contrast, non-strategic attack probabilities are exogenously provided. Extensive sensitivity analyses for optimal defensive resource allocations and expected property losses were conducted with regard to equity coefficient, cost-effectiveness of defense and budget.

Data Collection Techniques: We used expected property losses, population, density, density-weighted population data of 47 most valuable U.S. urban areas from Willis et al. (2004).

Results to Date: (a) Equity is costly; (b) Such equity costs increase convexly in the level of equity, and are higher when the defensive budget is lower and when the defense is less effective; and (c) per-target-equity is less costly compared to other types of equity.

Future Research: We plan work with DHS agency to implement the model to practice.

Reference:

- Willis, H. H., A. R. Morral, T. K. Kelly, and J. J. Medby. 2005.Estimating terrorism risk. URL http://www.rand.org/pubs/monographs/2005/RAND*MG.pdf*.
- Shan, X. and J. Zhuang. "Hybrid Defensive Resource Allocations in the Face of Partially Strategic Attackers, and Comparison with Fully Endogenous and Exogenous Model," presented at Operations Research for the Public Interest Conference, Stanford University, June 17-18, 2010; and invited to be submitted to *Operations Research* for a special issue on "Operations Research for the Public Interest."

Xiaojun (Gene) Shan is a Ph.D. candidate of industrial and systems engineering (ISE) at the University at Buffalo, The State University of New York. He has been a doctorate student in ISE since he obtained an M.A. in cognitive psychology and psycholinguistics from the University at Buffalo in Fall 2008. Gene's long-term research goal is to integrate game theory, operations research and cognitive psychology to guide decision-making processes. Gene's recent research interests include applications of game theory, psychological analysis and operations research methods to issues in homeland security, health care, transportation, logistics and supply chain management.

Potential Use of Chlorine Dioxide to Decontaminate Skin Surfaces in an Animal Mass Casualty Response

Jeannie M. Stubblefield and Anthony L. Newsome, Ph.D
[1]jeannie.stubblefield@yahoo.com, [2]anewsome@mtsu.edu
Middle Tennessee State University / Southeastern Regional Research Institute
Research Topic: Biological Threats and Countermeasures

Project Scope and Statement of Problem: The ability to timely and safely contain the spread of bacterial pathogens in an outbreak is a matter of high concern for national security as well as the national food supply. In this study, chlorine dioxide was evaluated as a means of decontaminating animal carcasses to decrease the risks involved in handling and disposing of mass casualties that have been contaminated with both naturally-occurring pathogens, as well as spore-forming bacterial pathogens that might be used in a deliberate terrorist attack or in a naturally-occurring outbreak. The use of chlorine dioxide as a decontaminant is not new. However, issues related to the safety of transport and expertise needed to generate it onsite have hindered its broad-scale consideration in local response scenarios. The recent development of a two-component sachet delivery system eliminates these problems, making it prudent to evaluate potential use in local response scenarios.

Methodology: Untreated pig skin samples were inoculated with the spore-forming bacteria *Bacillus atrophaeus* as a model for *Bacillus anthracis*, the causative agent for anthrax, and treated with various protocols using chlorine dioxide gas and solutions.

Data Collection: Skin surfaces were sampled using contact plates before and after treatments and numbers of colony forming units were evaluated to determine treatment efficacy. The abundance of naturally-occurring bacteria and structure of skin surfaces presented unique challenges in sampling and enumeration of bacteria. Methods were developed to standardize sampling of skin bacteria to more accurately quantify the treatment effectiveness.

Results: Results showed that chlorine dioxide gas is effective as both a decontaminant and as a sterilant for naturally-occurring skin bacteria as well as the spore-former *B. atrophaeus*. Spray and dip treatments utilizing chlorine dioxide solutions were effective in eliminating some naturally-occurring skin bacteria, but not effective in eliminating *B. atrophaeus.*

Conclusion: Additional research is needed to optimize broad-scale application protocols, but these results have clear applications for inclusion in outbreak responses to mitigate exposure risks in the handling and disposal of animal mass casualties whether as a result of a naturally-occurring outbreak or deliberate attack.

Jeannie Stubblefield is a senior at Middle Tennessee State University where she is completing a B.S. degree in biology with a concentration in microbiology. Following completion of her undergraduate studies, she intends to pursue a Ph.D. in microbiology with the ultimate goal of engaging in biomedical research and teaching. In addition to her primary research on decontamination protocols related to outbreaks such as anthrax, she has also participated in studies involving *Trypanosoma cruzi* detection in canines, control of food-borne pathogens using chlorine dioxide, and identification and culture of amoebal pathogens.

Oral Presentations

Visual Analytics Decision Support Environment for Epidemic Modeling and Response Evaluation

Shehzad Afzal, Ross Maciejewski, David S. Ebert (VACCINE PI)
safzal@purdue.edu, ebertd@ecn.purdue.edu
Purdue University, VACCINE COE
Research Topic: Advanced Data Analysis and Visualization

Project Scope: In modeling infectious diseases, scientists are studying the mechanisms by which diseases spread, predicting the future course of the outbreak, and evaluating strategies applied to control an epidemic. While recent work has focused on accurately modeling disease spread, little work has been performed in developing interactive decision support tools for analyzing the epidemic catastrophes and evaluating potential disease mitigation strategies. The absence of such tools makes it difficult for researchers, analysts and public health officials to evaluate response measures within outbreak scenarios. As such, our research focuses on the development of an interactive decision support environment in which users can explore epidemic models, mitigation strategies and the impact of both. This environment provides a spatiotemporal view where users can interactively utilize mitigative response measures, such as quarantine and transportation controls and observe the impact of their decision over time. Our system also provides users with doubly linked decision history visualization and navigation tools that support the simultaneous comparison of mortality and infection rates corresponding to different response measures at different points in time. The architecture of our system is flexible enough to model variety of epidemic catastrophes by integrating corresponding epidemiological models.

Methodology: Our system provides flexible decision history trees that can link to multiple simulation runs, interactive controls for exploring decision measures/interdiction points within the simulation and dually linked interactive displays. As the analyst explores the decision space, system keeps track of different decision paths and the corresponding mortality/sickness rates in a single visualization that helps identify optimal set of decisions.

Data Collection Techniques: We use hypothetical scenarios and dataset to perform our case studies. As the user inserts decisions points, scrolls through time, and revisits other scenarios, these interactions are tracked and displayed in the decision history view.

Results/Findings: Our case studies are the following: Pandemic Influenza with airline transportation and Rift Valley Fever, a mosquito-borne zoonotic disease. The results demonstrate the success of our system in designing effective mitigative strategies.

Conclusions, Future Research, and References: Our system helps users design both short term and long term decision strategies for epidemic catastrophes. In future, we plan to include an economic model into the system to visualize the impacts on local economy.

Shehzad Afzal received his B.Sc. (Hons) in computer science in 2002 and M.Sc. in computer science in 2007 from the University of Engineering and Technology, Lahore, Pakistan. He is currently pursuing a Ph.D. in computer science from Purdue University, West Lafayette, Indiana. He is currently working as a research assistant in 'Visual Analytics for Command, Control, and Interoperability Environments' Center (VACCINE) at Purdue University. His research interests include visual analytics, scientific visualization and computer graphics.

In Situ Device for Assessment of Scour Potential of Non-cohesive Sediments at Depth

Cary W. Caruso and M. A. Gabr
ccaruso@eos.ncsu.edu, COE PI: Rick Luettich, rick_luettich@unc.edu
Dept of Civil, Construction and Environmental Engineering NCSU
Natural Disasters, Coastal Infrastructure and Emergency Management (DIEM)
Research Area: System Observability, Diagnosis, and Prognosis

Project Scope: Analysis of the stability of highway bridge structures prior to, and after, storm events is critical for public safety. This is one of the lessons learned from infrastructure failures during and after Katarina. The scope of this project aims at the development of a portable device for measuring scour rates to allow for better prediction of the performance of costal hydraulic infrastructure during severe events such as floods and hurricanes. Such measurement allows for a more focused targeting of funds for identification, hardening, or remediation of highway bridges resulting in more effective expenditures and greater public safety.

Discussion on Methodology and Data Collection Techniques: A vertical probe (VP) employing a water jet has been developed for measuring scour potential with depth of sediments typically found at the bottom of rivers or streams. The premise is that analyses of the probe penetration rate into the soil correlates with scour rate and therefore, scour potential. Current techniques of measuring scour potential with depth require removal of soil samples for laboratory testing while other in situ approaches are limited to measuring scour on the surface of the sediment. The method discussed here measures the scour rate both in situ and as a function of depth. In addition, it can also be used in dry as well as saturated soils.

Results/Findings to Date: Results on test sands (mean particle diameter (D_{50} ~0.3 mm) suggest that the rate of the probe's advancement is proportional to the vertical velocity of the water at the tip of the probe raised to a positive exponent. For the saturated sand used in testing, the exponent appears to be 1.4. Scour rates also vary with moisture content. Thus far, in situ scour rates determined with this method for surface sands are consistent with scour rates published for other, similar sands. Measured in situ scour rates decrease as depth increases suggesting a relationship with effective stress. Results will also be presented from ISEP measurements in and around the 2003 Isabella breach from the Cape Hatteras Region of North Carolina.

Conclusion, Future Research, and References: Assessment of scour potential at critical civil infrastructure is a persistent challenge for the profession. The technique discussed in this research has been shown to be a quick and effective means of determining erosion rate as a function of depth allowing rapid determination of scour-critical sediments. Future research will concentrate on refining the methodology and extending the application to more complex materials and situations. Preliminary results have been presented at the Fifth International Conference on Scour and Erosion in San Francisco and a paper published in the conference proceedings. More recent results were accepted for presentation and publication at the GeoFrontiers 2011 meeting in Dallas during March of 2011.

Cary Caruso was born in Memphis, Tennessee, and as a youth lived in Tennessee, New York, Arkansas, and Ohio. He attended Southern Methodist University in Dallas, TX, where he received a BS in physics and an MS in geophysics. After 5 years working in the oil industry, he returned to school and received a PhD in geophysics from Cornell University in Ithaca, NY. He moved to Durham, NC, to pursue post-doctoral research at Duke University and, while there, fell in love with and married the girl next door. He taught for 12 years at local universities, and during this time they had a daughter. After a heart attack that triggered much soul-searching, he decided to switch fields. He started in civil engineering at NCSU in 2007 and was invited to work with Dr. Mohammad Gabr during 2009. The rest is yet to be written.

MUNICIPAL: A Decision Technology to Support Mitigation, Response, and Restoration Decisions

Burak Cavdaroglu, Ryan Loggins, Sehrish Khan
cavdab@rpi.edu
William A. Wallace, wallaw@rpi.edu
Rensselaer Polytechnic Institute; Natural Disasters, Coastal Infrastructure and Emergency Management (DIEM)
Research Area: Mitigation and Response

Project Scope: After a hurricane occurs, one of the most important ways to limit its impact is prompt and effective restoration of the services disrupted by the extreme event. The managers of Critical Civil Infrastructure (CCI) systems and emergency management officials are often faced with having to prioritize the restoration of essential services such as power, telecommunications, water, and transportation. The public needs timely restoration of these services in order for their community to recover from the impact of the hurricane. Therefore, it is important to develop decision technologies for these managers to support selection, scheduling and assignment of resources in response to the extreme event that disrupts the services of the CCI systems. MUNICIPAL (Multi-Network Interdependent Critical Infrastructure Program for the Analysis of Lifelines) is the decision support tool that we are developing to help communities become more resilient to hurricanes. MUNICIPAL enables infrastructure and emergency managers to visualize the CCI systems and their interdependencies and assess the damage caused by a hurricane to these systems. It supports their mitigation, response, and recovery decisions and helps ensure the resiliency of their community to an extreme event.

Discussion on Methodology: MUNICIPAL consists of three modules: (1) the vulnerability module, which models the impact of hurricane scenarios by converting weather information into hazards caused by the hurricane such as wind gust, flood and storm surge and estimating the impact of these hazards on CCI systems, (2) the optimization software which does the computational work to find the best scheduling and assignment for recovery and restoration, and (3) the GIS software which enables the users to view a map of CCI systems, the interdependencies among them, and the results found by the optimization software.

Discussion on Data Collection Techniques: We selected New Hanover County (NHC), North Carolina, as a case study region for the design and implementation of MUNICIPAL. The realistic representation of CCI systems in NHC is modeled based on the interviews with the Emergency Management Department of the county and the utility providers in the region.

Results/Findings to Date: We finalized a prototype of MUNICIPAL, which is capable of finding, in real time, the best restoration plan for disrupted infrastructures in New Hanover County for any given damage scenario.

Conclusion, Future Research, and References: Critical civil infrastructures are designed to support social systems such as healthcare and education, which are an inherent part of the resiliency of a community. We will integrate social systems into MUNICIPAL in order to better understand and manage a catastrophe‘s impact on society.

Burak Cavdaroglu is a PhD student majoring in industrial and systems engineering at Rensselaer Polytechnic Institute (RPI). He received his MS degree from the Department of Industrial Engineering & Operational Research at Koc University and BA degree from the Department of Industrial Engineering at Middle East Technical University. His research focuses on applications of disaster management. He is also interested in pharmaceutical marketing. He is currently working with Professor William A. Wallace on a CoE-DIEM project funded by the Department of Homeland Security. The purpose of the project is to design decision technologies for infrastructure and emergency managers to support their mitigation, response, and recovery decisions in response to extreme events.

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Analysis of Hazardous Material Incidents in the Gulf Coast Region: A Case Study of Houston, Texas

Latissha Clark
clarklv@tsu.edu, Carol Lewis, Ph.D., lewis_CA@tsu.edu
Texas Southern University, National Transportation Security Center of Excellence
Advanced Data Analysis and Visualization, Commerce and Infrastructure Resilience, Infrastructure Protection, Transportation Security

Project Scope/Problem Statement/Hypothesis: Petrochemical goods are included under the category of hazardous materials (HAZMAT). An estimated 800,000 shipments of HAZMAT occur every day. Data analyses and simulations can indicate patterns of incidents by using several different variables in the transport of these chemicals. Identifying the frequency enhances the pattern recognition to pinpoint potential dangerous situations. This research shows there is an opportunity to mitigate potential problems in the transport of petrochemicals or other hazardous materials.

Discussion on Methodology: Annual data are analyzed from the Pipeline and Hazardous Material Safety Administration (PHMSA), an agency that protects the public and environment by insuring the safe and secure movement of hazardous material goods. Aggregation of these data result in High Incident Zones (HIZ). The variables chosen from the original PHMSA data include the date, time, location, and mode.

Discussion on Data Collection Techniques: Reduction of the data required intensive secondary research to verify locations due to inconsistent reporting structures.

Results/Findings to Date: The data show potential clusters of incidents consistently towards late afternoon and during the summer months. Comparing the data before the categorization indicates overlapping HIZ while vehicles are in motion. Frequency clusters are used to identify overlapping incidents. The in-transit incidents are located in a specific cluster area of Houston around the I-10/I-610 corridors.

Conclusion, Future Research, and References: When identifying the mode with the largest amounts of incidents occurrence, *Highways* lead the other modes (Marine, Aviation, and Rail). A prominent factor that is confirmed in the data is that a majority of incidents happen while being static in nature (not in transport of any kind). Recommendations for future research include replicating this study in major cities and major petrochemical commerce areas and doing a comparison of the results. With this comparison study further clarification can be shed on the propensity of some zip codes being prone to high incidents as well as making a microscopic examination of street level incidents.

Latissha Clark is a graduate research assistant at Texas Southern University in the Transportation Studies Department. She obtained her Bachelor of Science degree in airway science management. Recently, in October 2010, Ms. Clark successfully defended her thesis entitled ―Analysis of Hazardous Material Incidents in the Gulf Coast Region: A Case Study of Houston Texas." Ms. Clark has interned as a student engineering technician at the Air Force Research Laboratory at Wright Patterson Air Force Base in Dayton, Ohio. Ms. Clark's research with the Air Force involved data mining techniques and Behavioral Learning Analysis for Simulated Tactics (BLAST). Ms Clark has also interned at the Houston District Office of Congresswoman Sheila Jackson Lee working with cases for district constituents involving veterans affairs and housing issues. Her internships also include the Dr. Ron E. McNair Educational Science Literacy Program (DREME) where she networked with local and national companies for the programs Annual Gala.

While pursuing her Master of Science in transportation planning and management at Texas Southern, Ms. Clark was the vice-president of the student chapter for the Institute of Transportation Engineers. As a transportation studies alumnus Ms. Clark served on the advisory board for Texas Southern University's Airway Science Program. She is also the recipient of the Dwight D. Eisenhower Transportation Fellowship and the National Transportation Defense Association Scholarship. Ms. Clark also serves as Young Member of the Transportation Research Board Task Force on Aviation Security and Emergency Management.

Study of Material Discrimination using Multi-Energy X-Ray Computed Tomography for Explosives Detection

Limor Eger[(1)], Synho Do[(2)], Prakash Ishwar[(1)], W. Clem Karl[(1)], Homer Pien[(2)]
Limor Eger, limor@bu.edu, PI: W. Clem Karl, wckarl@bu.edu
[(1)] Boston University, ALERT COE [(2)] Massachusetts General Hospital
Explosives Detection, Mitigation and Response

Project Scope/Problem Statement/Hypothesis: X-ray Computed Tomography (CT) is an effective non-destructive technology widely used for medical diagnosis and security purposes. With the use of CT, three-dimensional images of the inside of an object are generated based on its X-ray attenuation. Multi-Energy CT (MECT) is technology in which multiple energy-selective measurements of the X-ray attenuation can be obtained. MECT is also capable of providing information about the chemical composition of the scanned materials. These attributes make MECT an attractive tool for explosives detection in luggage, as well as for medical applications, such as improved differentiation between contrast and non-contrast filled regions.

Discussion on Methodology: We approach the problem of discriminating between explosives and non-explosives by studying the fundamental information content concerning materials that is available from MECT data. We focus on the X-ray attenuation versus energy curves of materials which MECT measurements are related to. We study the behavior of these curves and the discriminatory information available in them. The identification of the optimal choice of features to be extracted from the curves can inform the design of next generation MECT systems and estimation methods for explosives detection.

Discussion on Data Collection Techniques: We created a dataset of attenuation versus energy curves of materials with examples of explosives and non-explosives. We extracted different features of different dimensions from these curves and tested the resulting separability between the explosives and non-explosives.

Results/Findings to Date: We demonstrate that the material discrimination can be significantly improved by using more than two features and when using features different than the standard photoelectric and Compton coefficients. This suggests the potential for improved explosives detection performance relative to conventional dual-energy X-ray systems.

Conclusion, Future Research, and References: Directions for future work include further adaptation of learning-based techniques to the framework of explosives detection using MECT data and incorporation of the physical model of the MECT system into the detection algorithms.

Publications: L. Eger, S. Do, P. Ishwar, W. C. Karl, and H. Pien, "A learning-based approach to explosives detection using multi-energy X-ray computed tomography," *Submitted to ICASSP 2011.*

Limor Eger is a doctoral candidate working with Prof. W. Clem Karl of Boston University. Her research is on algorithms for the detection of explosives in luggage by multi-energy X-ray computed tomography, and is part of ALERT– a U.S. Department of Homeland Security Center of Excellence. Limor received an M.S. from Boston University and a B.Sc. from Ben-Gurion University, Israel.

Vocal Analysis Software for Rapid Security Screening: Validity and Credibility Assessment Potential

Aaron Elkins, Judee Burgoon, and Jay Nunamaker
aelkins@cmi.arizona.edu, jnunamaker@cmi.arizona.edu
University of Arizona, National Center for Border Security and Immigration
Human Factors

Project Scope: Vocal analysis software designed to automatically detect emotion and deception using the voice is gaining wider adoption by law enforcement and in rapid screening environments such as airports. However, most commercial vocal analysis software is developed independent of the scientific community and very few empirical attempts have been made to assess its validity and credibility assessment potential. This research explores the vocal measurements independent from the vocal analysis software's interface and built-in algorithms to determine their validity, composition, and potential to predict emotion, cognitive effort, stress, and deception in rapid security screening scenarios.

Methodology: Commercial vocal analysis software in use by U.S. law enforcement was implemented to segment audio recordings from a deception experiment with 96 subjects and 1,181 vocal responses to short answer questions. A multilevel factor analysis was performed to explore the factor structure. Custom regression and machine learning models for predicting deception using the vocal measurements were developed and tested.

Findings to Date: The vocal analysis software's built-in deception classifier performed at the chance level. When the vocal measurements were analyzed independent of the software's interface, the variables measuring stress, cognitive effort, and anticipation significantly differentiated between truth and deception. A logistic regression outperformed machine learning approaches to predicting deception with an accuracy up to 62%.

Conclusion: The results of the current study suggest that the claim that vocal analysis software measures stress, cognitive effort, or emotion cannot be completely dismissed. Despite the promising results of the vocal analysis software for deception detection, future research should investigate the validity of the measurements by manipulating stress, cognitive effort, and emotion directly.

Future Research: The ability for commercial and traditional vocal measures to measure arousal caused by cognitive dissonance is under exploration. A forced compliance paradigm experiment was completed (N = 49) were participants made counter-attitudinal arguments that were recorded and are currently being analyzed with vocal analysis software.

References: Elkins, A. (2010). Evaluating the Credibility Assessment Capability of Vocal Analysis Software. Forty-Third Annual Hawaii International Conference on System Sciences, January 5-8, 2010, Koloa, Kauai, Hawaii

Aaron Elkins is a 4th-year Ph.D. candidate in the Management Information Systems Department at the University of Arizona. Before coming to Arizona, Aaron spent five years as an IT manager and researcher for AVID, an educational non-profit in San Diego, California. Aaron is currently part of the research team with the National Center for Border Security and Immigration (BORDERS) where he focuses on detecting emotion and deceit using noncontact physiological and nonverbal behavior sensors. This includes systems development, machine learning, data fusion, signal processing, and statistical modeling. Aaron is also part of the Self and Attitudes Lab in the Psychology Department where he conducts experiments on human perception and the use of complex information systems such as automated deception detection systems. Aaron‘s research also focuses on the cognitive theory of deception and the moderating effect of culture on deceptive communication.

Vibration Based Damage Detection of Scour in Coastal Bridges

Adel H. Elsaid, Dr. Rudolf Seracino (COE PI)
ahelsaid@ncsu.edu, rudi_seracino@ncsu.edu
North Carolina State University
Center for Natural Disasters, Coastal Infrastructure & Emergency Management
Research topic: Community, Commerce and Infrastructure Resilience

Project Scope: The ability to ensure the resiliency and to predict the future performance of coastal bridges is very dependent on identifying damages in critical components of the bridge rapidly after an event. Traditional vibration based damage detection efforts focused mainly on the detection of fatigue cracking. Although detecting fatigue cracking is important, it does not contribute significantly to the total number of bridge failures in the United States. A critical review of the up-to-date literature showed that the hydraulic loading, including the scour, is responsible for about 50% of the failed bridges. To this end, the primary focus of this project is the development and evaluation of damage features capable of rapidly identifying and quantifying the extent of deterioration of critical coastal bridge structures due to scour at submerged piers following an extreme storm event.

Discussion: To develop the methodology, finite element models were built for a steel grid that represents a two-span coastal bridge. Each model represents a different level of scour. The steel grid was excited by an impact load, that represents the load induced by an impact hammer, and the acceleration data were recorded at each connection. A reference model was created that represents the healthy condition of the bridge before the event. The effect of the scour level on the response of the superstructure was studied. Different vibration based damage detection techniques were applied to study their sensitivity. It should be mentioned that previous researchers simulated scour as the total loss of the intermediate support since the traditional techniques were not sensitive enough to detect the scour level at its early stages. The proposed techniques were able to locate and assess the extent of scour from the response of the superstructure without the need for under water investigations. Preparations are underway for experimental laboratory testing of the proposed steel grid to confirm the finite element findings.

Conclusions: At the conclusion of this research project tools will be available to rapidly assess the condition of an existing bridge immediately following an extreme storm event. The tools will be used by bridge engineers and will facilitate the decision making process for FEMA and similar agencies in the context of assessing evacuation and first responders‘ routes.

Future Research: The proposed damage detection techniques will be applied to a more complex structure by performing field testing on a real coastal bridge. Nevertheless, the laboratory testing will be expanded to detect damages at the steel connections of the superstructure as well as scour of the substructure. Detecting the existence, location, and quantifying the extent of damage in bridges will provide a strong basis for predicting future performance of bridges based on their current operating conditions.

Adel H. Elsaid is a Ph.D. student working as a research assistant in the Department of Civil, Construction, and Environmental Engineering at North Carolina State University (NCSU). He received his bachelor‘s (2003) and master‘s degrees (2007) in structural engineering from Ain Shams University, Cairo, Egypt. He worked as a professional structural engineer in a consulting firm from 2003 to 2008 until he joined NCSU to pursue his PhD degree. He has published one journal paper and two conference papers.

Optimal Deployment and Protection of High-Speed Rail

Lance Fiondella, Sherif Tolba, Alex Byrd, Qixing Wang,
Sanguthevar Rajasekaran, and Reda Ammar
lfiondella@engr.uconn.edu, PI: Nicholas Lownes, nlownes@engr.uconn.edu
Institution: University of Connecticut NTSCOE: TRANSIT
Research Topic: Transportation Security

Project Scope/Problem Statement/Hypothesis: The ambitious goal to connect 80% of America with high-speed rail (HSR) in the next 25 years at a cost of $500 billion requires thoughtful planning. HSR will supplement automobile and aviation networks to meet projected growth in travel demand. Due to its high cost, protection of HSR must be treated upfront as an integral part of deployment studies. The goal of this research is to maximize the utility of HSR and minimize its vulnerability to human induced and natural disruptions. This approach will ensure transportation security, safeguarding the promised economic benefits.

Discussion on Methodology: The approach synthesizes several modeling and algorithmic techniques from civil engineering and computer science. Traffic congestion models from civil engineering characterize the impact of heavy traffic in automobile networks. This approach identifies the paths of least resistance, determining how travelers navigate from source to destination to minimize their commute time. As the unsuspecting travelers go about their daily lives, two omniscient entities engage in a game theoretic battle of plotting how to attack and defend network links [1]. At the end of this game, the defender knows which links in the network are most likely to be attacked. This gives the defender the power to assess the value of deploying various deterrence and protective technologies to lower the vulnerability of the network. These critical model features will capture the effects of introducing HSR into the network and protecting it, providing the tools necessary to compare alternative designs and effectively mitigate vulnerability.

Discussion on Data Collection Techniques: Several additional details will improve model accuracy. These include: empirical estimates of congestion in automobile networks, growth trends for intercity travel demand, cost projections for specific HSR lines and their protective technologies, and models for domestic aviation demand. Historical data from the Federal Bureau of Transportation Statistics is being drawn upon to create mathematical models.

Results/Findings to Date: The results indicate the proposed approach: (1) identifies combinations of one or more travel paths most attractive to the attacker(s), (2) determines capacity enhancements that alleviate congestion most appreciably, (3) quantifies network vulnerability, (4) accurately recommends locations for protective and deterrent technologies.

Conclusions and Future Research: The proposed approach supports network planning and protection. The ultimate goal is a model to guide HSR deployment that weighs the benefit of protecting new and existing elements of the national transportation infrastructure.

References: M. Bell, The Use of Game Theory to Measure the Vulnerability of Stochastic Networks, *IEEE Transactions on Reliability*, 52(1), pp. 63-68, 2003.

Lance Fiondella is a PhD student in the Department of Computer Science and Engineering, University of Connecticut, USA. He was a 2007 recipient of a scholarship from the IEEE Reliability Society. His research interests include reliability and performance engineering.

A Study of Small Vessel Threats using Acoustic and Electro-optic Technologies

Andreas Graber, Qing Li, Saiyam Shah, Walter Seme,
Ariel Marrero, Wojciech Czerwonka
Andreas Graber, University of Miami, a.graber@miami.edu
Dr. Barry Bunin, Barry.Bunin@stevens.edu
Dr. Alexander Sutin, Alexander.Sutin@stevens.edu
Stevens Institute of Technology and Center of Secure and Resilient Maritime Commerce
Research Topic: A Study of Small Vessel Threats using Acoustic and Electro-optic Technologies

In response to the potential vulnerability of the United States (US) borders, the US Department of Homeland Security (DHS) has made it a priority to improve technologies/strategies for border security, with maritime security serving as one of its major concerns. Historically, maritime safety and security policies have primarily focused on large commercial vessels. The potential use of small vessels, such as commercial fishing vessels or recreational boats, in terrorist-related activities has become of increase concern. To address some of the concerns that emerged from this security gap, the US DHS published the Small Vessel Security Strategy in April 2008. The first critical question towards Small Vessel Threats is ―How small is too small" regarding the size of the suspicious vessel? In the summer of 2010, a student summer research team was formed at the Center of Secure and Resilient Maritime Commerce, hosted by Stevens Institute of Technology. The team, named the Acoustics and Electro-Optics Team, conducted research on this topic, focusing on Acoustic and Electro-optic (AEO) Technologies.

The major task of AEO team is to detect, classify and track small vessels on the river by deploying Stevens Passive Acoustic Detection System (SPADES) along with infrared and CCTV cameras. After calibrating the acoustic system, test paths were conducted by a Steven's research vessel, the RV Savitsky. An experimental log with duration from July 12th to July 15th, 2010, recorded approximately 950 vessels on the Hudson River, with a focus on the traffic around Midtown Manhattan. Satellite passes were also conducted during the same period as a complementary approach to get an aerial view of the Hudson River, which affirmed that the acoustic and infrared camera recordings were correct. Once data was collected and recorded from the Hudson River, observations and results were made based on these findings to advance our understanding of reconnaissance strength of each technology toward small vessels.

How small is too small is an ambiguous question in the sense of acoustic and electro-optics because the size of an object is not as relevant as some other features such as ambient noise, sound that is produced, and thermal radiation that is emitted. It is also dependent on the quality of equipment that is used. For this research program the acoustic system utilized is capable of hearing anything from a ferry to a jet ski. For the infrared cameras that were used, anything from a person to a party boat could be seen. This was true for several kilometers.

Andreas Graber is currently a senior at the University of Miami studying computer engineering. During the summer of 2010, he attended the summer research institute for the National Center for Secure and Resilient Maritime Commerce hosted by Stevens Institute of Technology.

Disruptions to Rail- Impact Analysis and Decision Support (DRIADS)

Joseph (Jody) Holland and Di Miao
Jhh206@ps.msstate.edu, Bethany Stich, PhD, bstich@ps.msstate.edu
Mississippi State University- Southeast Region Research Initiative (SERRI)
Community, Commerce and Infrastructure Resilience

Project Scope/Problem Statement/Hypothesis: This research explores Homeland Security issues with regional transportation infrastructure decision-making and economic development potential within the State of Mississippi to improve community, commerce and infrastructure resiliency. The project examines disruption scenarios of critical rail infrastructure to determine a general overview of how man-made and/or natural disasters will affect transportation networks and regional economies.

Discussion on Methodology: First, the researchers utilized the Universal Rail Rerouting Model (URRM) provided by Oakridge National Laboratory (ORNL) to determine freight flow changes due to rail infrastructure disruptions. Once the disruption patterns were identified, the researchers were able to couple the URRM output data with regional economic models, Regional Economic Modeling, Inc. (REMI) and Economic Modeling Specialists, Inc. (EMSI), to determine the employment, income, and state tax revenue changes as well as additional economic impacts associated with the rail disruption. Finally, economic output data were utilized through a GIS application to provide mapping and visualizations comparing the baseline (no disruption) scenario and the rail disruption scenarios.

Discussion on Data Collection Techniques: Regarding the freight flow patterns, the URRM incorporates rail capacity and volume data to generate freight flow patterns. Using node and segment linkages, the researchers can simulate disruption patterns within the rail network. In addition, utilizing production cost changes, volume changes, and employment changes, the economic models (REMI and EMSI) can simulate the regional economic impacts, which are represented with mapping and visualization through GIS application.

Results/Findings to Date: This research has identified a process that visualizes and maps economic impacts due to rail disruptions. The findings highlighted interoperability between three robust modeling applications and determined various infrastructure and economic predictions that can enhance community, commerce and infrastructure resiliency.

Conclusion, Future Research, and References: The interoperability of these models provides decision makers with an efficient process to identify economic impacts related to rail disruption due to man-made and/or natural disasters. Future research should concentrate on transferring the automated decision modeling process to different regions of the nation that are dependent on rail infrastructure.

Joseph (Jody) Holland is a post-doctoral research associate at Mississippi State University (MSU). Holland received his Ph.D. from MSU. Currently, his research focuses on the integration of information technologies within transportation policy. Before concentrating on this effort, his research agenda included human resources management and non-profit management.

Deformation-Based Limit States for Earth Embankments

M. Khalilzad, M. A. Gabr, mkhalil@ncsu.edu
COE PI: Rick Luettich E-Mail: rick_luettich@unc.edu
Dept of Civil, Construction, and Environmental Engineering, NCSU
COE: Natural Disasters, Coastal Infrastructure and Emergency Management (DIEM)
Research Area: System Observability, Diagnosis, and Prognosis

In many cases, levees serve as protective structures adjacent to main roads and lifeline highway bridges. Damage to even a small section of a levee may result in the release of a large amount of water, stored in the reservoir, into the transportation network nearby and inundation of the area for a considerably long time. The effect of such failure and consequent repair costs of highway infrastructure can pose a financial challenge to cities and communities protected by these structures. Work in this project aims at defining performance limit states for the earth levees indicating functionality level with a given storm magnitude and providing a simplified framework for estimating the probability of unsatisfactory performance at each limit state.

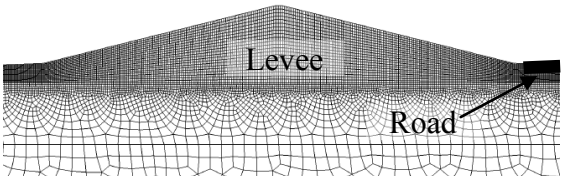

Figure 1. Finite Element Model of the Levee

An earth embankment is modeled using coupled flow/deformation analysis to capture the interdependency of under-seepage and through-seepage with deformation associated with the development of plastic zones and shear bands. Limit states are defined in terms of deformations and seepage gradients that correspond to the levels of performance or extent of damage in the embankment. In this analysis, no predefined limit equilibrium mode is being considered as the probable failure mode Thus, either deformations and hydraulic gradients are manifesting the *emerging failure mode* while the levee is subjected to a loading condition corresponding to a given storm event. Once emerging performance envelopes are defined on the basis of deformation /gradient levels, the deterministic analyses are extended to assess the probability of exceeding the proposed performance envelopes.

The analysis showed as the water level is increased in the reservoir, lateral displacement also increased and zones with high seepage velocity emerged at the entrance and exit locations of the dam. Depending on the statistical variation of input parameters, probabilities of exceeding limit states are calculated and presented for the case study. The increase in associated flow rates is also presented to indicate extent of functionality in relation to the water holding capacity. Such approach is informative in quantifying the level of safety corresponding to the current state of the levee and its anticipated performance under impending storms.

Mahdi Khalilzad is a Ph.D. student at North Carolina State University in geotechnical engineering. He has his M.Sc. in geotechnical engineering from University of Tehran and his B.S. in civil engineering from Iran University of Science and Technology. He is studying under the supervision of Dr. M. A. Gabr, working as his research assistant on the subject of coastal infrastructure protection and emergency management.

Coast Guard Search and Rescue Visual Analytics

Abish Malik, Ross Maciejewski, David S. Ebert
amalik@purdue.edu
PI: David S. Ebert, ebertd@purdue.edu
Purdue University, VACCINE COE
Research topic: Advanced Data Analysis and Visualization

Project Scope: To effectively manage crisis situations, analysts and decision makers need the ability to extract actionable information from multiple, massive datasets in order to prepare, plan, respond, and mitigate these situations. In order to ease the exploration of such datasets, advanced tool sets are required that allow users to interact with their data and assist them in their analysis.

Methodology: We present our collaborative work with the U.S. Coast Guard Ninth District and Atlantic Command where we developed a comprehensive visual analytics system to analyze the risks to maritime and public safety associated with the reallocation of available Coast Guard resources and shutting down of stations mandated due to budget changes, retiring volunteers, among other factors. The system included linked views and interactive displays that allow the interactive analysis of trends, patterns and anomalies among the U.S. Coast Guard search and rescue (SAR) operations and their associated sorties. Our system allows users to determine the potential increase or decrease in risks associated with shutting down certain station(s) in terms of factors including response times, potential lives and property lost and reallocation of available resources. The system also enables a thorough assessment of all SAR operations conducted by each U.S. Coast Guard station in the Great Lakes region. In addition, the system provides officials with the tools to determine which Coast Guard stations are more optimally suited to assume control of the operations of the closed station(s) by comparing the optimal transportation routes of the available stations to all SAR cases previously handled by the closed station(s).

Data: Our system has been developed using actual U.S. Coast Guard SAR data for the Great Lakes region.

Results and Conclusions: This project demonstrates the effectiveness of visual analytics in analyzing risk within the maritime domain. Our system provides analysts with a suite of tools for analyzing risks and consequences of taking major decisions that translate into important measures including potential lives lost and property damaged. Our system is currently being used by the U.S. Coast Guard Ninth District that is responsible for all Coast Guard operations throughout the five U.S. Great Lakes.

Future Work: Our short term future plans include deploying our system to assist in the analysis and optimization of all operations conducted by the U.S. Coast Guard Ninth District and expanding the use of this tool to other Coast Guard districts.

Abish Malik is a Ph.D. student in electrical and computer engineering at Purdue University. He works as a research assistant at the Visual Analytics for Command, Control, and Interoperability Environments (VACCINE), a U.S. Department of Homeland Security Center of Excellence. His research interests include visual analytics, information visualization and exploratory data analysis and visualization. Malik has a bachelor‘s degree in electrical engineering from Purdue University.

National Responses to September 11 over Time: Analyzing Changes in Emotions, Behaviors, and Beliefs

Shelly McArdle, Richard John, Heather Rosoff
smcardle@usc.edu
Mentor: Richard John, richardj@usc.edu
University of Southern California, CREATE
Risk, Economics, and Decision Sciences

Project Scope: Before 9/11, the small number of attacks and a limited number of people directly affected by the attacks left it unclear how Americans perceive the likelihood and consequences of terrorist attacks and how they might react and respond if they were to occur. September 11 created a natural experiment from which we can study the effects on the airline industry in real time; a real attack from which we can examine how the event affected people across the nation in different ways. With this information, we investigate the behaviors, emotions, and beliefs of people nationwide in response to the disastrous event in general as well as specifically to the airline industry.

Hypotheses: Using poll data collected consistently over the five years following 9/11, we further investigate the changes over time. We hypothesize that: A) There will be a time when the initial responses to the attacks shift – the heightened responses in reaction to September 11 will dissipate and plateau over time; B) Perceptions and behaviors will be moderated by age, sex, party, and region.

Methodology: The data used was derived the 9997 total participants of the ABC News‘s and CBS News‘s polls collected from September 12, 2001 until September 7, 2006. The current study investigates the responses to seven questions asked across 10 polls. The seven questions include emotional (concern about future attacks, worry about flying), behavioral (have respondents flown since 9/11, have they changed their actions), and cognitive (confidence in the government, value of civil liberties) responses to the terrorist events of September 11 over time. Respondents‘ answers to the seven poll questions were analyzed using independent, univariate ANOVA with each independent variable (time, sex, age, party, and region).

Results: A significant interaction with time was found in all but one of the poll questions. Each of the moderating variables also provided significant interactions with time. Finally, over time both the emotional and behavioral responses returned to a normal, even state after one year, while the changes in beliefs were still diminishing as late as September 2006.

Conclusions: This information is critical for providing insight into how citizens will perceive and respond to an attack on the airline system, and for contributing to the development of effective organizational policies and recovery. Further experimental research on the airlines‘ responses to attacks would be beneficial.

Shelly McArdle is an undergraduate senior at the University of Southern California. She is studying psychology and business while working with Dr. Richard John at the DHS CREATE Lab. While working at CREATE Shelly investigates risk perception and behavior changes over time in response to natural disasters or terrorist attacks. Shelly is currently applying to Ph.D. programs in organizational behavior to further investigate decision-making and group processes in a business and government setting. She is working on three papers for publication including two from CREATE as well as her senior honor‘s thesis. While not doing research, Shelly enjoys keeping busy as a scheduling manager, stage manager, and residential adviser as a few of her many jobs.

Infrastructure Protection and Prepositioning of Supplies for Disaster Relief

Hugh Medal, Chen Wang, Ed Pohl, Chase Rainwater, Scott Mason
Hugh.Medal@uark.edu: epohl@uark.edu
University of Arkansas, National Transportation Security Center of Excellence
Emergency Preparedness and Response

Project Scope: Two well-known strategies for preparing for catastrophes are prepositioning of relief supplies such as medicine, water, and food and the protection of infrastructure. While each of these strategies has been studied in the academic literature, they have generally been considered separately. Our hypothesis in this research is that making prepositioning and protection decisions in an integrated way offers improved insight that decision makers would not see when considering these decisions separately. In this work we integrate the prepositioning and protection decisions in a mathematical model to investigate our hypothesis.

Methodology: We model the prepositioning and protection decisions via a two-stage network flow model with failures. In the first stage of our model, the pre-event stage, relief supply storage facilities are located, supplies are prepositioned at various locations, and protection resources are allocated amongst the facilities. The occurrences of disasters occur randomly with respect to location and magnitude. A disaster results in demand for relief supplies at various points in the network as well as the degradation of infrastructure elements within the network. Elements that have been protected are less vulnerable to disasters. In the second stage, or post-event stage, relief goods are routed from storage facilities to the disaster site through the infrastructure elements in the network that are left intact. To solve our model we employ an L-shaped decomposition technique that is commonly utilized in stochastic programming. In addition, because our model is nonlinear, we apply linearization techniques to improve tractability.

Data Collection: We apply our model to a real-world case study. The transportation network considered in the case study is a model of the southeastern United States transportation network. The frequency and magnitude of disasters is based on historical data collected on hurricanes in this region.

Results to Date: We are currently in the experimental stage of our analysis and expect to be able to report results in time for the spring conference.

Conclusions: After completing our experimentation, we expect to provide empirical evidence of the benefit obtained from jointly considering prepositioning and protection. We hope that our results will help enhance organizations appreciation of the value of collaboration in preparing for disasters.

Hugh Medal is a Ph.D. candidate in the Department of Industrial Engineering at the University of Arkansas. His research interests include disaster preparedness and response, as well as designing and protecting transportation networks to enhance security. In his dissertation, Hugh is studying how to optimally design and protect transportation networks to make them resilient to catastrophes. His dissertation work can be applied in disaster relief, emergency medical services, as well as the commercial aviation sector. He is also interested in teaching and is planning on a career as a professor.

Novel Structural Control for Multi-hazard Protection

Preventing Blast-Induced Progressive Collapse and Improving Seismic Structural Response

Brent Meins: brentmeins@gmail.com
Adviser: Dr. Seokbin Lim, lim@nmt.edu
New Mexico Institute of Mining and Technology, Career Development Grant
Research Topic: Community, Commerce, and Infrastructure Resilience

Problem Statement: There are many existing buildings in the U.S. designed with little seismic protection. This deficit in lateral stiffness and energy absorption makes structures very susceptible to blast-induced progressive collapse as was seen in the Oklahoma City bombing. Existing structural controls do not address progressive collapse resistance as part of a multi-hazard design plan. The objective of this effort is to develop a comprehensive approach for progressive collapse analysis, and to use it to investigate a novel structural control system intended to improve structural integrity under abnormal loading conditions.

Methodology: The analysis approach is intended to predict extent of collapse based on characteristics of the blast and building using simple, non-numerical calculations. Additionally, a novel structural control system is designed as a retrofit option to prevent collapse. The proposed system incorporates diagonal cable braces attached to pin-in-slot connections and coupled to columns by springs. Inclusion of friction dampers provides energy dissipation, and continuity of cables through adjoining bays provides load path redundancy. As a passive system, it is intended to be an economical and feasible way to improve seismic structural response and prevent blast-induced progressive collapse.

Data Collection: Analysis is carried out in three parts: 1) calculating blast pressures/impulses on column faces, 2) determining if columns will collapse under this dynamic loading, and 3) analyzing collapse resistance of an entire building under gravity load with these columns removed. Analytical predictions are compared to hydrocode modeling and Oklahoma City collapse data for accuracy and validity. The control system is validated when design sizes to prevent collapse are reasonable for implementation as calculated by the analysis approach.

Results: Work completed to date includes comparison of analytical calculations to hydrocode modeling for determination of blast pressures/impulses and development of two methods for dynamic beam failure. Future work includes finalization of collapse analysis methods, seismic analysis, and detail design of control system utilizing previously validated approach.

Conclusion: The end product of this effort is proof of the effectiveness of the proposed system so it can be approved for use, and calculation guidelines for implementation to be provided to the end user. With low cost and infringement, this system can be easily implemented and has potential for saving many lives in a blast or seismic event on a municipal structure.

Brent Meins is in his second year as a master‘s student in explosives engineering at New Mexico Institute of Mining and Technology. He currently works as a research assistant operating a shock physics lab and is supported by the Department of Homeland Security Career Development Grant. With an undergraduate background in civil engineering, and current research and classes in explosives, his thesis topic is in blast effects on structures. His work in developing a novel structural control system aims to improve community resiliency through structural integrity under blast and seismic loading. He successfully completed the fundamentals of engineering exam and is enrolled as an engineering intern in the state of New Mexico. He hopes to begin work at a national lab next year in continuing to protect people and buildings from blast effects.

His professional experience outside of academia is in commercial sailboat operation. He is a licensed Master of commercial sailing vessels with experience in boat charters and competitive sailing.

He has been an active member of the student community at Tech. Previously serving as a Student Senator and officer of many student clubs, he enjoys ballroom dance, sailing, hiking, and skiing.

Decision Learning Algorithm for Acoustic Vessel Classification

Talmor Meir, Dr. Hady Salloum, Dr.Alexander Sutin
tmeir@stevens.edu, Hady.Salloum@stevens.edu
Stevens Institute of Technology, Maritime Security Laboratory, CSR
Research Area: Maritime and Port Security-Decision science

Project Scope: Marine transportation plays a vital role in the global economic viability of America. As a maritime nation, the United States depends on a strong commercial maritime industry that is tied to maritime security and its stability. Ports and affiliated transportation are all part of a complex system and are potential targets, with wide-scale disaster implications. A need to detect, track and classify vessels of all sizes approaching our ports and harbors is imperative to the security of this country and its complex maritime systems. This case study is an application of the passive acoustic method for vessel classification. The analysis of noise radiated by vessels is the constituent for a decision algorithm that classifies large vessels, small vessels and ferries in the Hudson River located in the busy maritime environment of New York City.

Methodology: Underwater acoustical signatures are used to design and train an automated decision learning software that classifies and monitors the vessels beyond a camera‘s visual field of view. Hydrophones lowered into the Hudson River across from NYC record acoustical signatures of passing vessels. Acoustic signatures are then processed through a signal analyzer using Detection of Modulation on Noise (DEMON) spectra to characterize significant traits affiliated with the different classes of vessels. Finally, the traits are fed into the nodes of the self learning algorithm system which initiates an alarm communication when a vessel is uncategorized or falls into a suspicious vessel domain.

Data Collection Techniques: Data of various ships was collected during the DHS Summer Research Institute of 2010 at Stevens Institute of Technology. The database is composed of acoustical signatures of approximately 950 ships accompanied by pictures, video and a record of related environmental conditions. Forty single boats were chosen for this case study; ten of which will form the foundation of the initial decision algorithm, twenty boats will be responsible for the training of the system and the final ten for testing the success rate of the self taught decision software.

Findings to Date: Specific vessel characterization is noted based on the distinct number of acoustical peaks, and associated frequencies and amplitudes. An analysis of acoustical signatures of 14 ferry boats has shown that there are currently two classes of ferries traveling the waters of the Hudson River. An Investigation of large vessels displays a common acoustical behavior of harmonic progressions.

Future Plans: Efforts to expand the classification of the algorithm nodes and type of vessels will extend this preliminary case study. This research has not yet been published.

Talmor (Tal) Meir is a graduate student in ocean engineering at Stevens Institute of Technology. She earned her B.Sc. in geophysics from Tel-Aviv University of Israel. At Tel-Aviv University she worked as a research assistant for the Department of Remote Sensing. Her interests include forecast modeling of urban surroundings and the communication and visual interchange of imperative data. In the summer of 2010, Tal took part in the CSR Summer Institute Research (SRI) with a concentration in acoustics for the maritime security domain. Within this context she is currently working on ship classification methods in the metropolitan area of New York City conducted at the Maritime Security Laboratory at Stevens Institute of Technology.

Integration of Household Decision Making with Dynamic Transportation Modeling to Evaluate Hurricane Evacuation

Thomas Montz, Vinayak Dixit, and Brian Wolshon
tmontz1@lsu.edu, PI: Brian Wolshon, Email: brian@rsip.lsu.edu
Louisiana State University
Natural Disasters, Coastal Infrastructure and Emergency Management (DIEM)
Emergency Preparedness and Response

Problem Statement: A need for more flexible evacuation plans has been recognized because of the current limited ability to accurately forecast hurricane movement and development as well as the variability in behavioral responses that govern the evacuation decision process. For any given disaster, different factors will influence the evacuee response (departure time, route selection and destination choice). The traditional approach to forming evacuation plans has been based on characteristics observed during previous hurricanes. However, developing more flexible and robust evacuation plans requires the use of evacuation behavior models that can predict evacuee response ahead of the storm. This also allows modelers to develop strategies based on the various behavioral responses and evaluate their operational effectiveness. This research investigates the first step toward more flexible evacuation plans by providing a bridge between evacuation demand modeling at the household decision-making level and traffic simulation with dynamic traffic assignment.

Methodology: The proposed methodology uses two separate logit models to predict hurricane evacuation demand and evacuation destination choice. These models were used to generate an overall evacuation demand distribution for New Orleans under a disaster scenario based on Hurricane Katrina. The demand conditions predicted by this technique were then modeled using the TRANSIMS computer software package to simulate the impacts of the evacuation traffic on a regional New Orleans network. The results of this predicted scenario were then directly compared to traffic observed during Hurricane Katrina. In addition, a base simulation model previously created by LSU researchers was also compared.

Data Collection: Traffic data observed during Hurricane Katrina was collected by the Louisiana Department of Transportation and Development during the evacuation by permanent vehicle count stations located throughout the state. Also, information about cities surrounding the New Orleans metropolitan area and the actual path of Hurricane Katrina needed to be collected. This information was used by the logit models described above to estimate both when evacuees would leave there home and to which city they would evacuate.

Results: The results suggest that the this new methodology was able to predict the spatiotemporal evacuation traffic patterns observed during the Hurricane Katrina evacuation of 2005 that are essentially accurate from the evacuation planning perspective.

Conclusions: This research was intended as a first step toward the development of more robust and flexible evacuation plans. Using this method, more elaborate hurricane scenarios can be created and simulated, giving emergency planners advance knowledge of what could happen during an evacuation.

Thomas Montz was born and raised in Mobile, AL, by parents native to Louisiana. When going through the college selection process, a clear choice was LSU as he was able to stay close to family but still move away from home. Mr. Montz excelled in his undergraduate career earning his Bachelor of Science degree in civil engineering with 3.79 GPA and graduating cum laude in the fall of 2009. Mr. Montz entered his graduate education directly after earning this degree and has been working on his master‘s degree in civil engineering with an emphasis on transportation since then. Mr. Montz‘s thesis research is currently focused on modeling hurricane evacuation, but he has also accepted additional research in the areas of traffic flow characteristics, traffic simulation, and work zones. In addition to academic merits, Mr. Montz has also held several internships at various levels of civil engineering. These include working for Bechtel, an international project management and construction firm, the Louisiana Department of Transportation and Development, and ABMB Engineers, a local engineering firm in Baton Rouge.

Decision Modeling for Optimizing Investments in Transportation Infrastructure Systems Vulnerable to Natural Hazards

Brian Piper, bepiper@ncsu.edu
PI: Ranji Ranjithan, ranji@ncsu.edu
North Carolina State University, Natural Disasters, Coastal Infrastructure and Emergency Management Center of Excellence (DIEM)
Risk, Economics, and Decision Sciences

Problem Statement: Civil infrastructure (CI) depends on the transportation system to deliver critical services during disruptions such as natural hazards. As such, it is vitally important that the transportation system be designed and maintained to be as resilient to hazards as possible. This is complicated by two factors: typical CI systems are highly interdependent, and the likelihoods and ranges of possible disruptions are not easy to obtain. Moreover, even defining how to measure system resilience is unclear. Can we model transportation system related CI investments and find those that confer the most transportation service resilience? Also, should the range and likelihood of possible damages be explicitly considered when making investment decisions, or is the extra cost to gather this data not worth the payoff?

Methodology: To quantify the idea of a resilient system being one that returns to acceptable service level after a disruption within a reasonable amount of time, we measure resilience as the recovery time for critical services to be back at functional levels. We consider a large range of disruptions over many time periods by using a multi-stage stochastic program. This mathematical optimization model is formulated to determine CI investments to minimize recovery time. These budget-restricted investments are made to improve the capacities of an existing transportation system over multiple periods of time and expedite restoration of the CI and the supported transportation system. An adaptation of Bender's method is used to solve the formulation in a computationally tractable manner. The solutions are compared to those obtained without explicitly considering ranges of disruptions to quantify the solution improvement gained by explicitly considering possible hazard event-driven disruptions.

Data: Several instances of general transportation network examples are modeled as multi-commodity network flow problems. Required data include the topology of each CI modeled, the costs and effects of investments on transportation system capacity, disruption possibilities and likelihoods, and services provided and required by various CI.

Results: Early results based on a sample set of test problems indicate that stochastic programs yield significant gains in transportation service resilience when compared with solutions obtained by a deterministic decision model, even for a relatively small investment budget.

Conclusion: The results demonstrate that explicitly incorporating uncertainties into the decision models has the potential to improve the resilience of transportation services supported by a CI system. A systematic sensitivity analysis will be conducted to study the solution characteristics given by this model across a range of instances and understand ways to enhance the effectiveness of resilience investments. The decision modeling investigation will be extended to additional applications and tested to evaluate the broader applicability to more realistic transportation networks and CI systems.

Brian Piper is a Ph.D. student in the operations research program at North Carolina State University. He received his MS in operations research from the program in 2009 and his BA in 2007 from Oberlin College. Research interests include civil infrastructure systems, optimization models, and decomposition solution algorithms. He is supported by a fellowship funded by a DHS Career Development Grant through NC State's Civil Engineering Department.

Aiding in the Prevention of Terrorist Attacks in the Hudson River through Detection of Small Vessels with UHF Radar

Angelica Sogor, Lenny Llauger, Omar Lopez, Shankar Nilakantan,
Danielle Holden, and Dakota Goldinger
aangelicaa@sbcglobal.net
Advisors: Dr. Scott Glenn, glenn@marine.rutgers.edu
Dr. Hugh Roarty, hroarty@marine.rutgers.edu
Center for Secure and Resilient Maritime Commerce, Stevens Institute of Technology
COE - Maritime, Island, Remote and Extreme Environment Security
Maritime and Port Security

The New York/New Jersey Port is the third busiest port with the most throughput in the United States, and the first busiest port on the east coast of the US. Having such a large impact on the economy of the US, it is important to protect the port and its components, including the Hudson River, from threats that would compromise the port's functioning. A predominant threat to the area can be found among small vessels, which often go undetected by technological means due to their small size, their low speed, and the absence of a requirement for those vessels to utilize AIS, the Automatic Identification System which identifies and tracks large vessels. Small vessels can be threats to port security if they illegally transport people (including terrorists), weapons, or drugs.

The research conducted utilized an Ultra High Frequency Radar system, the RiverSonde, developed by CODAR Ocean Sensors. The aim of the research was to find out whether small vessels could be detected using the RiverSonde.

Experiments with a small vessel (40 ft length) indicate the RiverSonde detected the test boat in the positive spectra (coming toward the radar) and in the negative spectra (moving away from the radar). The results also showed that the RiverSonde system can map surface currents of the river that matched an existing current model. In addition, the test boat was tracked successfully in various directions and velocities. Other boats that were traveling across the river were detected with similar precision, except when positioned perpendicular to the radar.

The use of one radar system is sufficient to identify the general location of a boat, but multiple RiverSonde systems can help triangulate the position of the boat in river. This paves the way for future researchers to develop a direction finding algorithm to estimate the position of the boat in the river. The use of multiple radars could give continuous updates on the movement of the vessels and allow tracking from one radar to another through the network, which can improve port security in the Hudson River.

Angelica Sogor graduated in December 2010 from the University of Miami with a Bachelor of Arts in marine affairs and policy, and with minors in economics and art. Beginning in January of 2011, she is continuing her studies at the University of Miami's Rosenstiel School of Marine and Atmospheric Science to pursue a Master of Science in marine affairs and policy. She has previously interned as a project manager with the South Florida Water Management District in Miami, FL, in 2009. Most recently in 2010, she was a member of the Summer Research Institute at the Center for Secure and Resilient Maritime Commerce at Stevens Institute of Technology in Hoboken, NJ.

Mitigating Risk in Multi-modal Perishable Commodity Supply Chain Networks

Jessica Spicer, Ed Pohl, Ph.D., Scott Mason, Ph.D.,
Chase Rainwater, Ph.D., Ashlea Bennett, Ph.D., Dia St. John
jbentz@uark.edu, epohl@uark.edu
University of Arkansas, National Transportation Security Center of Excellence
Community, Commerce and Infrastructure Resilience

Project Scope: The Mississippi River carries 90% of domestic corn destined for export, representing approximately half of the total freight tonnage transported along the upper Mississippi.[1] The disruption of services along the upper Mississippi could therefore have significant and undesirable economic consequences. Risk-mitigation actions can help reduce the cost of disruptions, but often require expensive investments, thus at-risk components must be prioritized to maximize system resiliency. Our goal is to develop decision support models that identify and prioritize critical infrastructure elements susceptible to threats of natural disaster. These models will assist decision makers in allocating risk-mitigation resources amongst multi-modal transportation infrastructure components.

Methodology: To develop a resource allocation strategy, we propose a multi-period mathematical model that determines how and when to secure key infrastructure assets on the upper Mississippi River in light of the multiple modes of transportation available.

Data Collection Techniques: To evaluate the performance of our preliminary model, we have randomly generated several classes of input parameters that account for a range of time-varying demand patterns. Data specific to the ports, dams, bridges and locks on the Mississippi River has been obtained through various public domain databases. This information is being used to construct a network representation of the flow of goods along the Mississippi River.

Results: To date we have successfully extended standard fortification models found in the literature to incorporate multi-period, budgetary, and post-reinforcement fallibility concerns. We continue work to include perishability and multi-modal impacts. Our decision support model will culminate in the combination of these extensions.

Conclusion and Future Research: The first phase of our project focuses on supply chain disruptions caused by natural disasters. We will next extend this research to make risk-mitigation decisions when confronted with unknown and adaptive adversarial objectives. These disruption scenarios, along with perishability, multi-period, and multi-modal concerns represent our unique contributions to infrastructure resilience planning.

[1]Frittelli, J.F. 2005. CRS Report for Congress. Grain Transport: Modal Trends and Infrastructure Implications. January 5, 2005

Jessica Spicer received a B.S. degree in mathematics from the University of Arkansas in 2010 and is currently a first year master‘s student in industrial engineering at the University of Arkansas. Her research interests are in modeling and optimization applied to the areas of disaster preparedness, healthcare, and transportation network security.

A Non-rotational Approach to Computed Tomography

Zachary Sun, W. Clem Karl
wckarl@bu.edu, zsun86@bu.edu
Boston University, Awareness and Localization of Explosives-Related Threats (ALERT)
Explosives Detection

Problem Statement: Volumetric CT machines have been shown to improve localization of various materials in checked-bags over standard planar radiography. However due to the size and power constraints, current systems are not as viable for carry-on bags. We seek to develop a system that can accomplish computed tomography within the constraints of current carry-on screening requirements.

Methodology: By pursuing a non-rotational computed tomography we eliminate the need for a cumbersome rotating gantry. Our setup utilizes the lateral movement of a simulated conveyor belt to create the angular diversity for a CT problem as shown with Figure 1. Since this is a limited angle tomography problem, direct methods are infeasible. Instead, we formulate this problem as a system of equations modeled as ray traces of x-ray photons using Siddon's method[1]. We solve the system by using iterative Krylov methods such as generalized minimal residual algorithm (GMRES)[1].

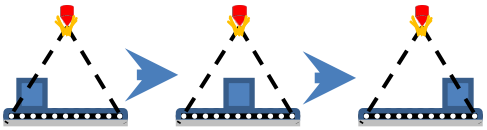

Figure 1: Proposed Setup for Non-Rotational CT

Data Collection: Data was simulated from volumetric data of a suitcase taken with a medical helical CT scanner.

Preliminary Results:

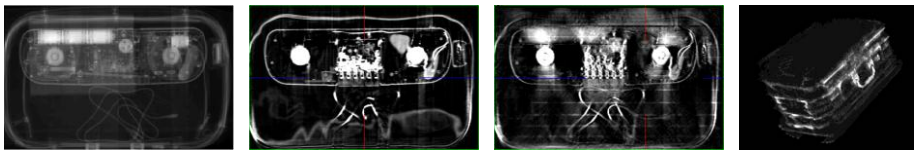

Figure 2: a) Simulated Planar Radiogram, b) Data slice from helical scanner.
c) Reconstructed slice with our approach, d) Render of reconstructed 3D volume

Conclusion: We have shown some preliminary success at retrieving 3D volumetric information without the use of a rotating gantry. Future work revolves around preconditioning to speed up rate of convergence along with regularization for artifact reduction.

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[2] Saad, Y., Schultz, M.H. (1986): GMRES a generalized minimal residual algorithm for solving nonsymmetric linear systems. SIAM J. Sci. Stat. Comput.**7**, 856-869

Zachary Sun is currently a third-year Ph.D. candidate at Boston University working with Professor Clem Karl as a part of the Department of Homeland Security‘s Center of Excellence ALERT. He received his B.S. from Tufts University in 2008 while majoring in electrical engineering, mathematics, and biomedical engineering. As a part of ALERT, Zach has been working on explosives detection in luggage through the use of x-ray computed tomography with a focus towards carry-on luggage as well as object recognition algorithms for advanced imaging technology systems. His current research interests include inverse problems, stochastic modeling, and stereo imagery with applications towards medical and security image processing.

Non-invasive Screening for Concealed Information

Nathan W. Twyman, Douglas Derrick, Jay F. Nunamaker, PI
ntwyman@cmi.arizona.edu, jnunamaker@cmi.arizona.edu
University of Arizona: National Center for Border Security and Immigration (BORDERS)
Topic: Border Security

Project Scope; Many current methods of screening for human security threats are more invasive that desirable, and tend to require more manpower than is available. We extend the same theories used to develop the polygraph[3] and combine them with behavioral theories of deception detection to create a standard, automated process for detecting concealed information in a rapid screening environment. This process uses non-invasive tools and techniques to determine a traveler's probability of concealing a threat.

Methodology: Qualitative interviewing with professional screening agencies and agents, together with a review of the theoretical literature informed the creation of basic models for this project. Detailed laboratory experiments have been conducted to test the accuracy of these models, as well as testing the effectiveness and accuracy of non-invasive instruments for measurement. Analyses from these experiments have led to the design of a rapid screening Concealed Information Test (CIT).[1] Experiments using this design are underway, and field experiments will follow.

Data Collection Techniques: Laboratory experiments have been used to collect data on the accuracy of rapid screening techniques and tools. In one such experiment, participants committed a realistic mock crime, and were then interviewed by a professional from the Defense Academy for Credibility Assessment (DACA). Various technologies measured the interviewee's thermal indicators, blood pressure, pulse, body movement, pupil diameter, blink rates and patterns, linguistic indicators, and vocalic (voice) indicators of veracity. A current experiment uses some of these measures in a rapid screening scenario, where travelers pack an improvised explosive device (IED) and bring it through a screening station. The screening station employs the rapid screening CIT design.

Results/Findings to Date: A simple model based on body movement reflected up to 80% accuracy in detecting concealed information after the realistic mock crime.[4] Ocular, vocalic, and pulse measurements also showed accuracies greater than that of professionals in various contexts. Ocular measurements using a CIT show particular promise.[2]

Conclusion and Future Directions: Kinesic indicators of deception can be significant even in a rapid screening situation. Eye movement can reveal concealed information. The CIT has been successfully adapted to a rapid screening scenario, with promising results. Future research will focus on 1) fusion of these indicators and 2) field implementations.

References: [1] see G. Ben-Shakhar and E. Elaad, "The validity of psychophysiological detection of information with the Guilty Knowledge Test: A meta-analytic review", Journal of Applied Psychology, 88 (2003), pp. 131-151.
[2] D. C. Derrick, K. Moffitt, J. F. Nunamaker Jr., "Eye Gaze Behavior as a Guilty Knowledge Test: Initial Exploration for Use in Automated, Kiosk-based Screening", *HICSS.* Jan 4-7, 2011, Koloa, HI.
[3] E. N. Sokolov, "Higher Nervous Functions - Orienting Reflex", Annual Review of Physiology, 25 (1963), pp. 545-&.
[4] N. Twyman, A. Elkins, J. Burgoon, "A Rigidity Detection System for the Guilty Knowledge Test", *HICSS.* Jan 4-7, 2011, Koloa, HI.

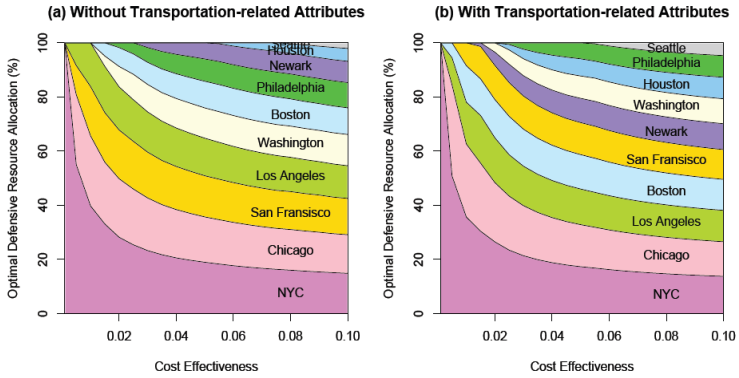
Nathan Twyman is a research associate in the Center for the Management of Information Systems in the Eller College of Management at the University of Arizona in Tucson. His current research interests include discovery of hidden information, human-virtual agent interaction, security technologies, virtual structures for collaborative decision making, and leveraging hedonic systems in organizations. In academic and professional experience, and in his personal life, Nathan emphasizes pragmatic ideas that challenge the limits of current understanding.

Optimal Defensive Resource Allocations in the Face of Uncertain Terrorist Preferences with Emphasis on Transportation

Chen Wang, Vicki M. Bier (COE Investigator)
cwang37@wisc.edu, ntwyman@cmi.arizona.edu
University of Wisconsin-Madison
National Center for Risk and Economic Analysis of Terrorism Events (CREATE)
Risk, Economics, and Decision Sciences

Project Scope/Methodology: This study extends current game-theoretic methods for identifying optimal defensive resource allocations to use realistic multi-attribute terrorist objective functions. In particular, we compare the optimal defensive resource allocations in the face of uncertain terrorist preferences with and without transportation-related attributes. The defender's uncertainty about terrorist preferences is addressed both by probability distributions over the attacker's attribute weights, and by allowing for attributes that are important to the attacker but not known to the defender.

Findings to Date: We conducted a case study on ten major US urban areas based on two different sets of attributes: macro attributes only (expected property losses from terrorist attacks and population density, on the left); and macro attributes plus transportation-related attributes (average daily air departures and average daily bridge traffic, on the right). Preliminary results indicate that taking into account terrorists' preferences for transportation-related targets leads to different resource allocations than would be predicted using only high-level attributes such as property damage and population density. In particular, cities with significant transportation-related infrastructure (e.g., Boston and Newark) can justify significantly higher levels of investment than they would have received considering only macro-level or generic attributes. Moreover, models that include transportation-related attributes can explain a higher percentage of the variation in expert judgments of target attractiveness than models without transportation attributes, even when the transportation attributes receive significantly less weight than the generic attributes.



Future Plans: We propose to further explore how the weight placed on transportation-related attributes affects optimal resource allocations, and also hope to use probabilistic inversion to elicit decision-maker beliefs about terrorist preferences in order to develop realistic estimates of attribute weights.

Publication: Wang and Bier, "Impact of Intelligence on Target-Hardening Decisions Based on Multi-Attribute Terrorist Utility," under revision for *Decision Analysis*.

Chen Wang is a PhD student in the Department of Industrial and Systems Engineering at the University of Wisconsin-Madison. Her current research interest is in the application of operations research, risk analysis and expert elicitation in homeland security problems.

A Many to Many Game Theory Approach to Measuring Transportation Network Vulnerability

Qixing Wang, Lance Fiondella, Alex Byrd, Sherif Tolba,
Sanguthevar Rajasekaran, and Reda Ammar
Student E-mail: qiw09005@engr.uconn.edu
Principal Investigator: Nicholas Lownes (nlownes@engr.uconn.edu)
Institution: University of Connecticut NTSCOE: TRANSIT
Research Topic: Transportation Security

Project Scope/Problem Statement/Hypothesis: Transportation network security is a continued and growing concern across the world due to the increase in terrorist attacks over past several decades. There are many possible targets and one can never be certain where the next attack will come. Measuring transportation vulnerability is the first step to proactive prevention. In the transportation networks, the vulnerable links will be those which play a critical role and are the most likely to be attacked. This project will provide the method needed to identify critical links so that they can be protected.

Discussion on Methodology: The relationship between terrorism and anti-terrorism can be modeled as a game between two opponents. Game theory mathematically captures the players‘ strategy in order to predict possible terrorist scenarios. We adopt a game-theoretic framework and create a program to describe a measure of network vulnerability. To make the measurements more realistic, all of the possible trips between each origin and destination (O-D) locations must be considered. In the program, we assume two opponents in a non-cooperative, zero-sum game with symmetric information. The router represents DHS, who seeks to ensure safety and efficiency on all paths for all travelers. The tester represents the terrorists who wish to disable certain edges in the network to maximally disrupt network performance. Based on many-to-many demand, Frank-Wolfe all-pair shortest path algorithm considers edge utilization and cost. Method of Successive Averages (MSA) and weighted entropy function are employed to guarantee the game converges to a solution. These methods will assist DHS to assess transportation network vulnerability, thereby preventing catastrophic attacks.

Discussion on Data Collection Techniques: GIS data is being employed to create massive test problems to validate the scalability of our algorithms.

Results/Findings to Date: Results indicate the approach rapidly identifies vulnerable links in large city-scale transportation networks, including (Sioux Fall network: 24 nodes, 76 edges and 552 O-D pairs) and (Anaheim, CA network: 416 nodes, 914 edges and 1406 O-D pairs).

Conclusion and Future Research: Congestion effects will be incorporated into future studies. This will improve the defensive strategy. Technology deployment algorithms will provide decision support for infrastructure hardening applications.

Qixing Wang is a second-year graduate student in the Civil & Environmental Engineering Department at the University of Connecticut. Since September 2009 he has worked on transportation network vulnerability under the supervision of Dr. Lownes.

Full-Scale Airport Security Checkpoint Surveillance using a Camera Network

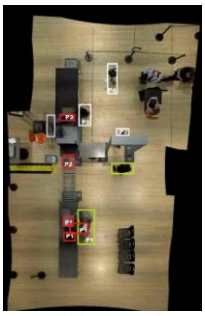
Ziyan Wu, Keri Eustis, Andrew Calcutt, Eric Ameres, Richard J. Radke
wuz5@rpi.edu, (518)961-1754
Richard J. Radke, rjradke@ecse.rpi.edu, (518)276-6483
Rensselaer Polytechnic Institute, ALERT COE
Transportation Security

Project Scope: This project proposes an airport security checkpoint monitor system. The research goals include tracking and monitoring passenger behavior, associating baggage with passengers, and detecting abnormal issues. The system can potentially significantly reduce the workload and increase the efficiency of airport security checkpoints, and monitor the protection of passengers' property.


Full-scale Simulation Environment

Discussion on Methodology: A camera network consisting of 19 cameras is designed for the surveillance system, which is calibrated using a scale bar, fundamental matrix estimation and an improved non-linear optimization procedure. A Mixture of Gaussians method is adopted to model the background of the large mosaic of the floor, thus moving objects can be effectively tracked by background subtraction. In order to associate bags to passengers, the image area is divided into several areas, each of which is monitored by algorithms to track the movements of labeled bags and passengers. When the passenger leaves the checkpoint, a decision is made indicating whether the passenger has picked up the right bags.

Discussion on Data Collection Techniques: Several groups of volunteers participated in a full-scale environment simulation as passengers. They were asked to go through the checkpoint with baggage as they do at real airport. Each round of simulation was recorded by the camera network. Additionally, some passengers were asked to act abnormally like mistakenly picking up another's bag or putting prohibited items in their bags. More than 10 hours and 300GB of multi-camera video clips were collected during the one month simulation.


Tracking Result

Results: The algorithm has been tested on 3 complete runs of the simulation. 46 passengers and 55 bags were tracked and analyzed. The results show that one false alarm and no false positives in associating 51 bags. However 4 bags failed to track and ended without decision because they were merged into a bin by passengers or taken away by staff.

Conclusion and Future Research: The project has combined a full-scale airport security checkpoint monitoring environment with a camera network tracking system. Experimental results show that generally the design works well to track and associate bags with passengers. We are currently investigating more advance scenarios found in the dataset, and designing algorithms to handle more the complicated behaviors that may occur in practice.

Ziyan Wu is currently a Ph.D. student at Rensselaer Polytechnic Institute majoring in computer and systems engineering. His research focuses on computer vision, object tracking and camera network, under the supervision of Prof. Richard J. Radke. He received his master‘s and bachelor‘s degrees in electrical engineering from Beihang University, China, in 2006 and 2002, respectively. He is a member of IEEE and ACM.

Consequence Assessment for Complex Food Transportation System Facing Catastrophic Disruptions

Yu Zhang, PI, Alan Erera
zhangyu@gatech.edu, alan.erera@isye.gatech.edu
Georgia Institute of Technology
Program Affiliation: National Center for Food Protection and Defense
Research topic: Catastrophes and Complex Systems

Project Scope: Our research aims to identify and determine how to understand the potentially severe economic impact risks in complex transportation systems for U.S. food supply chains, with the intent of enabling significant improvement in food supply chain security, preparedness and resiliency. In the study, we focus specifically on three primary export field crops—corn, soybeans and wheat—from farm to export port. Models are developed to assess the vulnerability of critical infrastructure and key resources (CI/KR) in the transportation system, where vulnerability in this case is measured by the potential for large supply chain cost increases given disruption. Understanding vulnerabilities in the system is important for the effective allocation of protection investment.

Methodology: Our methodology for supply chain vulnerability assessment is based on a network model, which attempts to predict how freight flows are diverted when disruptions occur (either natural disasters or intentional attacks). The vulnerability of selected targets is assessed by parametric optimization analyses and then represented by impact curves, which depict the relationship between the consequence of the disruption and its magnitude.

Data Collection: Export flows of U.S. grains rely on a complex transportation network, comprised primarily of railroads and inland barge routes, while moving through the mainland U.S. en route to an export port. The data used in this research is obtained from public data sources available from agencies, such as USDA, USDOT, USACE.

Conclusion/Findings: The targets for the vulnerability assessment are a section of dams and locks on the Mississippi River system due to their criticality in the transportation system. We apply the methodology to this set of potential targets, and have determined consequence impact curves for each target. Given the input data, we find a small set of targets that are significantly more vulnerable than others.These components should be prioritized for protection against disruptions from intentional attacks or natural hazards.

Future Plans: Our next research step focuses on developing methodology for preventing and mitigating the risk of natural or man-made disasters through better supply chain design and protection.

Yu Zhang is a Ph.D. student in the School of Industrial and Systems Engineering at the Georgia Institute of Technology. He received his B.S. Eng. from Huazhong University of Science and Technology (Wuhan, China). He currently serves as a research assistant at ISyE's Supply Chain and Logistics Institute.

His research focuses primarily on transportation and logistics systems planning and control, with a focus both on innovative modeling and solution methodologies, and on challenging application areas including robust service network design, integrating security and efficiency in logistics systems.

Centers of Excellence

2011 Homeland Security Centers of Excellence

The **National Center for Risk and Economic Analysis of Terrorism Events (CREATE)**, led by the University of Southern California, develops advanced tools to evaluate the risks, costs and consequences of terrorism, and guides economically viable investments in countermeasures that will make our nation safer and more secure.

The **Center of Excellence for Zoonotic and Animal Disease Defense (ZADD)**, co-led by Texas A&M University and Kansas State University, protects against the introduction of high-consequence foreign animal and zoonotic diseases into the United States, with an emphasis on threat awareness, protective countermeasures, and surveillance.

The **National Center for Food Protection and Defense (NCFPD)**, led by the University of Minnesota, defends the safety and security of the food system from pre-farm inputs through consumption by establishing best practices, developing new tools and attracting new researchers to prevent, manage and respond to food contamination events.

The **National Consortium for the Study of Terrorism and Responses to Terrorism (START)**, led by the University of Maryland, informs decisions on how to disrupt terrorists and terrorist groups, while strengthening the resilience of U.S. citizens to terrorist attacks.

The **Center for Advancing Microbial Risk Assessment (CAMRA)**, led by Michigan State University, Drexel University, and established jointly with the U.S. Environmental Protection Agency, fills critical gaps in risk assessments for decontaminating microbiological threats — such as plague and anthrax — answering the question, "How Clean is Safe?"

The **National Center for the Study of Preparedness and Catastrophic Event Response (PACER)**, led by Johns Hopkins University, optimizes our nation's preparedness in the event of a high-consequence natural or man-made disaster, as well as develops guidelines to best alleviate the effects of such an event.

The **Center of Excellence for Awareness & Location of Explosives-Related Threats (ALERT)**, led by Northeastern University in Boston, Massachusetts, and the University of Rhode Island in Kingston, Rhode Island, will develop new means and methods to protect the nation from explosives-related threats, focusing on detecting leave-behind improvised explosive devices, enhancing aviation cargo security, providing next-generation baggage screening, detecting liquid explosives, and enhancing suspicious passenger identification.

The **National Center for Border Security and Immigration (NCBSI),** led by the University of Arizona in Tucson (research co-lead) and the University of Texas at El Paso (education co-lead), is developing technologies, tools and advanced methods to balance immigration and commerce with effective border security, as well as to assess threats and vulnerabilities, improve surveillance and screening, analyze immigration trends, and enhance policy and law enforcement efforts.

The **Center for Maritime, Island and Remote and Extreme Environment Security (MIREES)**, led by the University of Hawaii in Honolulu for maritime and island security and by the Stevens Institute of Technology in Hoboken, New Jersey, for port security, will strengthen maritime domain awareness and safeguard populations and properties unique to U.S. islands, ports, and remote and extreme environments.

The **Coastal Hazards Center of Excellence**, led by the University of North Carolina at Chapel Hill and by Jackson State University in Jackson, Mississippi, will enhance the nation's ability to safeguard populations, properties, and economies as it relates to the consequences of catastrophic natural disasters.

The **National Transportation Security Center of Excellence (NTSCOE)**, was established in accordance with HR1, Implementing the Recommendations of the 9/11 Commission Act of 2007, in August 2007. NTSCOE is made up of seven institutions: Connecticut Transportation Institute at the University of Connecticut, Tougaloo College, Texas Southern University, National Transit Institute at Rutgers - The State University of New Jersey, Homeland Security Management Institute at Long Island University, Mack Blackwell National Rural Transportation Study Center at the University of Arkansas and the Mineta Transportation Institute at San José State University. The NTSCOE will develop new technologies, tools and advanced methods to defend, protect and increase the resilience of the nation's multi-modal transportation infrastructure and education and training baselines for transportation security geared towards transit employees and professionals.

The Center of Excellence in **Command, Control and Interoperability (CCI)** led by Purdue University (visualization sciences co-lead) and Rutgers University (data sciences co-lead) will create the scientific basis and enduring technologies needed to analyze massive amounts of information from multiple sources to more reliably detect threats to the security of the nation and its infrastructures, and to the health and welfare of its populace. These new technologies will also improve the dissemination of both information and related technologies.