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Improving Facilities Management Management (not a typo!) with an Electronic Performance Measures System

Client: Mark Webb, UVa Facilities Management

Faculty Advisor: Reid Bailey

ITAR/Citizenship Restriction? [Yes/No] No

Project Description

As noted on their website, “Facilities Management Operations provides a broad range of services in support of the University’s medical, academic, research and service missions. The department is made up of professionals in traditional physical plant shops trained to handle normal building maintenance, custodial, landscaping services and renovations for the University of Virginia.”

To manage work orders and resources, Facilities Management Operations uses an electronic database system. This system gathers an immense amount of data about work orders, such as date requested, date completed, and who performed the work. While the electronic database systems is used currently to track such work, Facilities Management Operations staff believe that the stored data could also be used to more use their resources more effectively and efficiently. In particular, the creation of performance measures from the existing data for supervisors is viewed as an untapped, valuable use of the existing data.

The capstone team will define, create, implement, and test the creation of a performance metrics system that uses existing electronic data to help Facilities Management Operations become more efficient and effective.

This is a good project if you want to work closely with your client on a capstone. The team will work with with decision-makers at Facilities and also with their IT staff (whom will help the team implement their ideas and integrate them into the existing database).
Mental Health Resources and the Criminal Justice System: Assessment and Plan for Integration in Charlottesville, Virginia – Phase III Expansion

Client: Thomas L. von Hemert, Criminal Justice Planner, Thomas Jefferson Area Community Criminal Justice Board

Faculty Advisor: Reid Bailey and Michael Smith

ITAR/Citizenship Restriction? [Yes/No] No

Project Description
During the past two years, capstone teams and graduate students have helped the Thomas Jefferson Area Community Criminal Justice Board by structuring a systems evaluation tool for a new program that they have developed called Crisis Intervention Training (CIT). CIT is a training program for police officers that focuses on how to handle situations with people experiencing a mental health crisis.

In their April, 2007 report submitted to the CIT Taskforce, an Evaluation Team comprised of 4th year University of Virginia Systems and Information Engineering students offered recommendations for improving the interfaces and interactions among the various agencies where consumers and their families may receive or be sent to receive either mental health or related services.

The key recommendation was that the CIT Taskforce implement a Crisis Intervention System (CIS) in the Charlottesville area. A CIS seeks to deliver a continuum of mental healthcare to individuals with mental illness in the community through the collaboration of the mental health and criminal justice systems. The development of a CIS requires the cooperation of the many agencies that are represented on the Taskforce.

Based on the April 2007 report, an evaluation tool (written in Excel with Visual Basic macros) was developed during the following year. This tool provides a means for multiple agencies to submit necessary data to the CIT coordinator and for the coordinator to import that data. Furthermore, the tool calculates and presents key metrics to the CIT coordinator at multiple levels: a top level view shows overall trends while more detailed graphs show specific aspects of the overall trends.

While the evaluation tool has been a giant step forwards, there are three areas of improvement on which the proposed work will focus.

- First, the tool itself needs refining to collect more detailed and consistent data while minimizing the time commitment of the various agencies that are submitting the data. This part is primarily focused on human factors.
- Second, the tool currently evaluates the impact of the CIT on the CIS only in City of Charlottesville and Albemarle Counties. The tool should be expanded to include seven additional counties, all part of the jurisdiction of Offender Aid and Restoration (OAR) Jefferson Area Community Corrections (the agency through which the CIT Taskforce is coordinated). This part of the project will involve significant interaction with individuals.
from the seven counties and should result in an expanded evaluation tool that incorporates relevant, available information from the additional counties.

- Finally, it has become clear that while the tool collects and presents valuable information with respect to how consumers are routed through the CIS and the resources used, the tool is disconnected from economic and cost issues. For example, when more consumers go to the hospital instead of to jail, what are the cost implications for each agency? The third part of the project is exploring how to connect the data in the tool to costs.

The intent is to pursue all three of these directions in the fall semester, with a more focused development of a subset of the directions during the spring (based on the feasibility determined during the fall term).

This project is ideal for students wanting to apply classical systems engineering approaches to a social system while working with a very hands-on client.
Client: Curry School of Education

Faculty Advisor: Peter Beling

ITAR/Citizenship Restriction? No

Project Description

Researchers in the Curry School of Education at UVA have established a program known as the Classroom Assessment Scoring System (CLASS) for improvement of teacher performance in the classroom. CLASS has as its basis an analysis of classroom environment and dynamics to identify key markers of teaching and learning effectiveness. Several large studies have established that CLASS markers are strongly correlated with objective measures of student academic performance, and instructors who engage in guided self-evaluation based on identified markers show significant improvement in performance. To date, the process of identifying and documenting markers has been dependent on the efforts of trained evaluators. This Capstone project will focus on the development of technological alternatives to expert evaluation, with the goal of demonstrating that evaluations and feedback to instructors can come from automated analysis of video from cameras placed in the classroom.

A key notion in CLASS is that instructors can review their classroom performance offline by viewing a DVD that is a time-sequenced collection of annotated video and audio clips from the classroom. Clips should be selected to be exemplars of behavior or conditions that are deemed most important by the scoring systems. To automate the production of an annotated DVD, we will need to make use of statistical algorithms designed to recognize objects in images and video. The output of the recognition algorithms may input to a scoring model. Statistical scoring is a predictive technology that has seen widespread use in financial risk management, fraud detection, and other applications. The score provides an assessment of the probability of occurrence for the event of interest, and in our case might be the basis for selecting whether or not a particular clip of video is included on the DVD.
TRACK-BASED CHARACTERIZATION OF VEHICLE BEHAVIOR

Client: Department of Defense

Faculty Advisor: Peter Beling

ITAR/Citizenship Restriction? Yes (rank this at the bottom if not a US citizen)

Project Description

In real-time surveillance it is often the case that the number of video streams available for viewing greatly exceeds the number of analysts available to view those streams. The question faced by each individual analyst is one of deciding which geographic scene to view and deciding which objects or activities within the scene should be the focus of attention. This project will focus on the design, implementation, and testing of an experimental decision support system that would rapidly sift through surveillance video as an aid to cue analyst attention. Central interest will be on surveillance scenarios in which persistent video is available from airborne platforms. With imagery of this type, the characterization of behavior will be based primarily on the analysis of vehicle tracks within the scenes under surveillance. We will also make use of simulated dated produced by a model of urban vehicle traffic. Part of the project will involve the design and implementation of an interface for displaying behavior characterization results on Google Earth.

Scoring models will likely be the basis of the technical approach. Scoring is a statistical predictive technology that has seen widespread use in financial risk management, fraud detection, and other applications. Scoring models are constructed by identifying a set of characteristics and associated attributes values that are predictive of an event or outcome of interest. A set of weights is then derived for each attribute value and these weights are used in turn to score new data as it becomes available. The score provides an assessment of the probability of occurrence for the event of interest. Attributes for the scoring model will be defined in terms of time-dependent statistics associated with the collection of object tracks. To take a concrete example, one characteristic of the score for an individual vehicle might be defined to assess the likelihood that the vehicle is in a caravan. Attribute values for this characteristic might then be calculated on the basis of the fraction of time that the vehicle spent during its sojourn through the scene in close proximity to each of the other vehicles. To account for the possibility of traffic congestion, this statistic could be normalized by the average observed for all vehicles that had been observed in the scene over a given historical period. The statistic would then give an indication of the degree to which the behavior of the vehicle in question deviates from normal behavior. Similar characteristics and attributes can be defined for other vehicle behaviors or for locations or geographic regions.
A TRAVEL ROUTE PLANNER THAT ACCOUNTS FOR TRAFFIC VARIABILITY

Client: Palo Alto Research Center

Faculty Advisor: Randy Cogill

ITAR/Citizenship Restriction? No

Project Description:

In this project we will design and implement a new travel route planner, similar to those offered by MapQuest and Google Maps. The difference between this planner and existing planners is that we will account for variability of traffic conditions when planning routes. One measure of variability that we may consider is the statistical variance in the travel time associated with a route. The planner that we will design will offer the user several route options, each balancing the trade-off between expected travel time and variance in travel time.

To give an example illustrating the difference between routes, suppose you want to drive from Charlottesville to Boston. Assuming that you will encounter average traffic conditions, taking route 29N to 95N will be the fastest route. However, certain points along this route experience highly variable levels of congestion. Traffic on the New Jersey Turnpike before the George Washington bridge sometimes moves smoothly, but sometimes comes to a complete standstill. Congestion experienced in this area could add several hours to your trip. On the other hand, to get to Boston you could take 64W to 81N, eventually crossing the Hudson river at the Tappan Zee bridge. While this route takes about \( \frac{1}{2} \) hour longer on average, the total travel time seems to be much more predictable.

The deliverable of this project will be a web-based application that will allow users to enter origin and destination coordinates, and will provide several travel routes between these points. To complete this project, the team will need to develop a strong understanding of:

- **Web-based applications**: Design of user interfaces using HTML, display of routes using KML and Google Maps, basic scripting with PHP
- **Databases**: SQL, Matlab's database toolbox
- **Optimization algorithms**: Shortest path algorithms (Bellman-Ford, Dijkstra's algorithm) and variants such as the A* algorithm, implementation in Matlab
- **Statistics**: Estimation of travel time statistics from traffic count data
- **Probability**: Construction of probabilistic models of travel time
2009-06  **ANONYMITY AS A FACILITATOR FOR COVERT AND ILLICIT INTERNET PAYMENTS AND COMMUNICATIONS**

**Client:** Booz Allen Hamilton  

**Faculty Advisor:** Jamie Conklin / Don Brown  

**ITAR/Citizenship Restriction?** Yes – US citizenship required  (rank this at the bottom if not a US citizen)

**Project Description**  
Historically, law enforcement has found that "following the money" as it flows into, within, and out of criminal organizations to be the most effective tool in their arsenal for halting these organizations' effectiveness. The money flows reveal their supporting mechanisms, relationships, and eventually their leadership. Other tools are then applied to disrupt these organizations. These actions rely on the assumption that traditional banking and money transfer and laundering systems are used. The use of traditional communications mechanisms (such as phone, fax, and mail) is also relied upon for interdiction, tapping, and bugging.

We are now in the age of transnational terrorism and crime, enabled and empowered through the fiber optic backbones submerged across the world's oceans in the 1990s. The Internet is one of the most powerful manifestations of this explosion of international connectedness. The Internet in its base form is a seemingly anonymous medium for communications, shopping, entertainment and other purposes. This is deceiving, as IP addresses can be tracked, cookies and malware can identify and locate you, and unencrypted emails can be read. The intelligence and law enforcement community relies upon these vulnerabilities to monitor targets of interest. This defensive bulwark against online anarchy is beginning to crumble.

Covert and anonymous communications and non-traditional banking mechanisms are beginning to proliferate and are being used by those criminal and terrorist groups who were previously held in check through these various counter-measures. Networked virtual environments (NVEs) such as Second Life now give individuals the ability to cloak themselves in anonymous personae and communicate, coordinate and even recruit through these virtual worlds. Additional systems are being created specifically to accommodate anonymous communications and money transfers. These systems are proliferating and becoming layered, linking and assisting the functionality of the each other, and facilitating the effectiveness of transnational criminals and terrorists.

**Objective:** Countering the threat posed by these anonymous communications and financial systems require understanding them first. The team will chart and project where this terra incognita is headed. Ultimately, this will result in strategies to counter the illicit use of these systems.
2009-07  OPTIMIZING FIRST RESPONDER RADIO NETWORK OPERATION

Client: Tyco Electronics

Faculty Advisor: Jamie Conklin / Don Brown

ITAR/Citizenship Restriction? Yes – US citizenship required (rank this at the bottom if not a US citizen)

Project Description
Tyco Electronics designs, manufactures and installs private wireless radio networks for emergency critical communications. Think of any police television show: walkie-talkies, 911 dispatch consoles and siren and light bars on the vehicles. Typical customers include cities, states, utility companies and military base operations.

These networks offer a multitude of features from which customers may choose. Some features are implemented at the network level while others at the radio terminal level. Selecting the features and coordinating network and terminal set-up is one of the major challenges for System Engineers and customers during installation and commissioning.

Customers have operated radio systems for many years but are now upgrading to networks, which represent a paradigm shift from:
- Analog to digital voice;
- Voice-only to voice-and-data operations;
- Standalone radio systems for each agency to integrated networks for all agencies;
- Emergency response from a single agency to multi-agency responses, and
- Local-centric focus to regional-centric cooperation.

A large number of decisions are required that are beyond the scope of prior experience. The customer and System Engineer need tools to guide the decision process for defining network operation. For example, each mobile and portable radio may be programmed during installation for the primary operating groups, but also include additional groups that anticipate emergency operations. If the groups defined initially prove to be inadequate or wrong, each radio must be “touched” for reprogramming, an expensive and time consuming process.

The objective for this capstone project is to develop an interactive feature selection and configuration to assist the customer and System Engineer during implementation. Currently printed technical manuals are provided for each piece of equipment, but this presentation is static. Capstone students will also develop displays to visualize the interaction and implications of changes in configuration of these systems.

The students will work across functional groups on this project: Design Engineers to learn network and radio capabilities; System Engineers to understand customer requirements; and Technical Writers and Test Engineers to develop simulation scripts. This capstone will be of interest to students who want to work on man/machine interface issues, optimization problems, and web services. Students selected for this team will have the satisfaction of knowing that their work will improve First Responder’s safety and ability to serve citizens.
Client: JAUNT

Faculty Advisor: Kenneth G. Crowther

ITAR/Citizenship Restriction? No

Project Description
Jaunt is one of the oldest regional transportation organizations in the region, providing more than thirty years of service to the populations of Charlottesville and surrounding communities. The transportation organization makes over 250,000 trips each year, carrying riders to work, doctor's appointments, shopping and other leisure activities. They use complex algorithms to ensure both (1) the cost and environmental savings of ride sharing and (2) the convenience of trips customized by pick-up and drop-off location and time. In the recent decade the demand for such customized services has accelerated, requiring Jaunt to constantly evaluate their spatial and temporal allocation of resources and adapt their operations to be able to provide greater cost and environmental savings and greater flexibility. This has resulted in large investments in database and information systems and large amounts of data are acquired on a daily and weekly basis. Participants of this project will work with the Executive Director of Jaunt and associated staff to design a decision support system that will support the decisionmaking of their executive and operations staff to adapt to the dynamics of regional transportation demands.

The students will understand and develop objectives within the organization and understand the decision processes that the organization uses to accomplish these objectives. Students will then design a set of decision support concepts and operations that will be the foundation for the decision support system, given the data that is gathered through operations. These concepts and operations will be implemented using Jaunt's Crystal Server. The students will be expected to design tests to assure that the implementation of the decision support system provides improved operations in terms of decreased decision time, increased overall productivity, and improved decision reliability. The final outcome of the project will be a system design for decision support system that sits on top of an existing database schema and fits into existing organizational processes. Individual student theses might focus on the specific aspects of database design, decision analysis, and user interface design, among others. Jaunt is committed to provide the resources necessary for the students to succeed in this critical project for the growth of customize regional transportation systems.
DEVELOPMENT OF EXECUTIVE PLAN FOR THE IMPLEMENTATION OF A COLLABORATIVE VIRGINIA CRITICAL INFRASTRUCTURE PROTECTION AND RESILIENCE STRATEGY

Client: Virginia Governor’s Office of Commonwealth Preparedness

Faculty Advisor: Kenneth G. Crowther

ITAR/Citizenship Restriction? Yes – vUS Citizens only (rank this at the bottom if not a US citizen)

Project Description
The Commonwealth of Virginia is a trusted leader in implementing homeland security and critical infrastructure protection strategies. For this and other reasons, Virginia has been requested by the US Department of Homeland Security to develop a statewide infrastructure protection strategy that resembles core components from related federal plans with adaptations that strengthen focus on collaboration, infrastructure interdependency, and regional resilience. Similar plans will be adapted in the coming years to other states across the US. To date, numerous interdependencies/risk assessments for critical infrastructure/key resources (CI/KR) have been completed statewide at varying levels of granularity. These include over fifty sites under the Buffer Zone Protection Plan (BZPP) Program as well as areas completed by the University of Virginia Center for Risk Management of Engineering Systems. With the development and initial implementation of the Virginia Critical Infrastructure Protection and Resiliency Strategic Plan (VCIPRSP) to comply with the National Infrastructure Protection Plan (NIPP) and the Virginia Executive Order 44 (EO44), there is a need for systems-driven, risk-based methods of analysis to support the development of the VCIPRSP and accompanying sector specific plans.

The goal of this project is to provide the Commonwealth of Virginia with generalizable, systems-driven and risk-based methods of analysis to offer guidance and assistance to the Virginia Governor’s Office of Commonwealth Preparedness (OCP), Sector Specific Agencies (SSAs), and industry partners with which to achieve the following objectives: (1) Identify and prioritize critical sector interdependencies and provide risk analysis of key sectors across the Commonwealth. (2) Provide systems-driven and risk-based analyses of the tradeoffs among investments in various protective measures and in resilience, addressing the acceptable recovery times and costs. (3) Assist in the development and implementation of the Commonwealth Sector Specific Plans (per the NIPP) and the VCIPRSP. (4) Provide community leaders and emergency managers with capabilities to analyze interdependent systems. (5) Include participation from private industry. (6) Deploy the developed methods to selected key sectors and identify the lessons learned, in order to enable planning for a more detailed studies. (7) Assist the Commonwealth of Virginia to provide leadership in the guidance of the ‘Homeland Security Management System’ in the development of policy, strategy, doctrine, and planning for the SSAs.

Students participating on this project will collaborate with state and local leaders as well as the private sector to investigate and establish the necessary knowledge base for the development and deployment of Sector Specific Plans across the Commonwealth based on principles of systems engineering and risk analysis.
2009-10 **FINANCIAL SYSTEM ANALYSIS**

**Client:** Jon Simonds, Algorithms Research Corporation

**Faculty Advisor:** Ginger Davis

**ITAR/Citizenship Restriction?** [Yes/No] No

**Project Description**

Today’s global financial market is vastly different from that of ten years ago. Investors must use massive amounts of continuously-collected data along with trading strategies in order to be profitable. Developing these trading strategies can be difficult since the financial system is very complex with many variables and interdependencies among these variables. This project will explore the complex financial system including the subareas of developing prototypical investment strategies, implementing those strategies via analytics software, developing agent interaction methodologies (risk management and money management), as well as working with an order management system.

Students involved in this project should have one or more of the following skills: computer programming, financial system / investment knowledge, and statistical knowledge.
Client: David Marchette, Naval Surface Warfare Center

Faculty Advisor: Ginger Davis

ITAR/Citizenship Restriction? [Yes/No] No

Project Description

An unknown number of attacks on government computer networks occur every day. Some of these attacks are successful and/or undetected and can have disastrous consequences. One of the aims of this project is to detect and ultimately prevent these attacks.

In today’s digital age, we are surrounded by massive amounts of data. In many cases, we do not know the best way to store, manage, integrate, obtain information from, or visualize it. Such is the case for data regarding packet flows over a network. Research involving the analysis of this type of data is in its early stages. Interesting problems such as behavioral authentication of server flows and intrusion detection are beginning to be solved using this type of data. We are particularly interested in analyzing network data for the purposes of anomaly detection (attacks, masquerades, and network interruptions), user profiling, workload management, and application verification. Our tasks include:

1) processing the data consisting of packets into a useful format
2) extracting information from the data flows
3) developing traffic flow models for the purposes mentioned above
4) visualizing the data
5) recognizing data patterns for the purposes mentioned above.

The client for this project is David Marchette, principal scientist at the Naval Surface Warfare Center. Students involved in this project should have one or more of the following skills: computer programming, hacking knowledge, computer networking experience, and statistical knowledge.
Classical techniques for ensuring secure communication in wired networks can not be easily extended to peer-to-peer wireless networks. In these networks, power-constrained devices must prioritize processing tasks and the quality of communication links maybe highly variable. Traditional techniques require significant processing and high quality communication links. In this project we are particularly interested in developing schemes for secure routing in heterogeneous peer-to-peer wireless networks. Building upon the ideas first proposed by Di Caro et. al. (2005) and Gunes et al. (2002) we have recently developed a new dynamic routing scheme based upon the notion of “rational swarms”. In a similar manner to ant-colony based routing protocols, estimates of link quality are maintained by using “ant” packets. However, in our protocol, every intermediate node behaves in an autonomous fashion and directs incoming traffic through adjacent links with the best current estimate of source-destination route quality. The goal of this project is to develop and implement security enhancing features to the “rational swarms” protocol. Empirical evidence obtained either via simulations and/or testbed implementation will serve to evaluate the proposed new features.

Keywords: Dynamic programming, shortest paths, learning, distributed computing.

References

2009-13  DESIGNING AND EVALUATING SIMULATION TRAINING FOR MEDICAL PROFESSIONALS

Client: Dr. Marcus Martin (UVa, Medicine) and Prof. Reba Childress (UVa, Nursing)

Faculty Advisor: Gregory Gerling

ITAR/Citizenship Restriction: None

Project Description:

Medical education is undergoing a revolution. The amount of knowledge young physicians and nurses in training must master is growing exponentially as are expectations for their performance, yet the amount of time they can devote to their studies is not. Knowledge that formerly was gained by interaction with patients must be taught more efficiently. To help clinicians acquire knowledge earlier, schools are turning to simulators that mimic the symptoms of disease, before students encounter a patient.

Training in simulated environments can improve task performance and patient outcomes while reducing risks. Graded levels of task difficulty, immediate and post performance feedback to users, and a range of anatomically and disease accurate scenarios are all important considerations in addition to basic human-machine interaction issues. The current generation of simulators, however, often fails to consider these issues or the increasing demands of learners.

One method of training involves using virtual reality and force feedback. Basically, a force-feedback device (e.g., SensAble OMNI) transfers mechanical forces to a user's hands, representing the sensation of impact and vibration. The user views a 3D environment on a computer screen and may visualize the interaction he feels with his hands. In the context of medical simulation, forces represent contact interactions with organs and skin. Force feedback simulation has been used for removing shattered kidneys, suturing tissues, and making incisions for cardiology and neurosurgery procedures.

At UVa, a basic framework is being established for simulating chest tube insertion, one procedure employed frequently and with great importance in emergency medicine. The goal of this project is to define, build, and evaluate training procedures and performance metrics so that a simulated environment can be employed to train all UVa medical and nursing students to high levels of proficiency.

Systems analysis and development tasks to be performed include:

a) refining the 3D human-machine interface and evaluating its usability
b) defining operator performance metrics
c) implementing a stochastic algorithm to characterize operator performance
d) designing an experiment to be conducted with medical/nursing students and using statistical data analysis

The above are to be implemented in software for the force-feedback device (in C/C++, Matlab, and OpenGL).

Throughout the project, the team will consult with the clients, selected professors and doctors, and medical and nursing students at UVa. There is an opportunity to present findings at a conference away from UVa.
2009-14  RISK-BASED RELIABILITY MODELING OF BRIDGE SYSTEMS

Client: Virginia Department of Transportation

Faculty Advisors:
Yacov Y. Haimes, L. R. Quarles Professor of Systems and Information Engineering
Founding Director, Center for Risk Management of Engineering Systems
Joost R. Santos, Research Assistant Professor, Systems and Information Engineering

ITAR/Citizenship Restriction? [Yes] US Citizens only (rank this at the bottom if not a US citizen)

Project Description

Among various physical and social infrastructure systems, the reliability of thousands of bridges in the U.S. has been diagnosed as low and unsafe. Indeed, the catastrophic bridge failure in Minnesota in August 2007 calls for an urgent need to develop comprehensive engineering-based risk analysis on bridge systems in order to prevent such future tragic events and to manage the nation’s bridge systems effectively. In addition, bridge infrastructure failures, whether caused by natural, manmade, or accidental events can propagate across interdependent socioeconomic systems across multiple regions.

The most recent issue of the ASCE Infrastructure Report Card¹ [ASCE 2005] estimates that $1.6 trillion is required over the next five-year horizon to enhance the safety of U.S. infrastructure systems. Of the twelve infrastructure categories assessed in the report, the highway infrastructure system (which includes bridges) is ranked as the top concern. According to the December 2007 National Bridge Inventory (NBI), the Commonwealth of Virginia has ownership to 13,418 bridges of which 3,442 bridges are classified into a group of deficient bridges, which represent approximately 25% of total bridges in Virginia (see details in Table 1). Limited funding sources require policymakers to prioritize allocation of available budget for deteriorating U.S. infrastructure systems. Developing engineering-based criteria can provide policymakers with effective and scientifically-sound tools for prioritization of maintenance and rehabilitation of bridge systems.

Table 1. Count of Bridges by Condition in Virginia and U.S.

<table>
<thead>
<tr>
<th>State</th>
<th>All Bridges (number)</th>
<th>Structurally Deficient (number)</th>
<th>Functionally Obsolete (number)</th>
<th>Percent of State Bridges</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIRGINIA</td>
<td>13,418</td>
<td>1,208</td>
<td>2,234</td>
<td>9%</td>
</tr>
<tr>
<td>UNITED STATES</td>
<td>599,790</td>
<td>72,523</td>
<td>79,798</td>
<td>12%</td>
</tr>
<tr>
<td>TOTAL*</td>
<td></td>
<td></td>
<td></td>
<td>13%</td>
</tr>
</tbody>
</table>

Note: * includes Puerto Rico.

In this Capstone project, students will work with engineers and domain experts from the Virginia Department of Transportation (VDOT) and the Virginia Transportation Research Council (VTRC). Learning about engineering structures of a variety of bridges, and gaining experience in the deployment of systems-driven and risk-based models, tools, and methodologies would markedly strengthen the students’ systems engineering knowledge-base and professional competence. The Capstone team will be mentored and will be made knowledgeable on

¹ http://www.asce.org/reportcard/2005/index.cfm
fundamental reliability and risk methodologies, such as Fault Tree Analysis, Factor of Safety (FoS), and Rating Factor (RF), among others.
ANALYSIS OF INTELLIGENCE DATA USING COORDINATED HIERARCHICAL BAYESIAN MODELING AND RISK ANALYSIS

Client: National Reconnaissance Office
Faculty Advisor:
Yacov Y. Haimes, L. R. Quarles Professor of Systems and Information Engineering
Founding Director, Center for Risk Management of Engineering Systems

ITAR/Citizenship Restriction? [Yes] (rank this at the bottom if not a US citizen)

Project Description
This project will apply and extend the Coordinated Hierarchical Bayesian Model (CHBM) [Yan and Haimes 2008] to enhance the data analysis capability of our intelligence community. The expected outcome is that through using CHBM, we will be able to increase the accuracy of incident predictions with more confidence through efficient integration of multiple data sources. This will make the intelligence actionable earlier, hence increasing the ability to disrupt enemy operations by getting inside the enemy’s decision cycle.

If you know the enemy and know yourself, you need not fear the result of a hundred battles. If you know yourself but not the enemy, for every victory gained you will also suffer a defeat. If you know neither the enemy nor yourself, you will succumb in every battle.
- Sun Tzu

Never before in history has intelligence been more critical and more difficult to analyze. A fundamental difficulty in the business of intelligence is distinguishing data from intelligence. Often there is a plethora of data which produces very little actionable intelligence. Sorting through the mountains of data and finding what specifically relates to the threat usually results in a much smaller database with which to conduct analysis. In the realm of risk analysis of extreme events such as major terrorist attacks, the data is whittled down so much, there is scarcely enough to be confident of a prediction and even less likely to deem that analysis to be actionable. CHBM is an analysis technique which aims to overcome the problem of scarceness of data by using the observed data and “borrowing” data from other related subsystems, observed from multiple perspectives, then coordinating the results to increase accuracy and confidence in predictions.

In this capstone project, students will work with, and gain experience from intelligence professionals from the National Reconnaissance Office and other US Intelligence agencies. Using the CHBM in conjunction with a Risk Based Methodology for Scenario Tracking [Haimes and Horowitz, 2002] will significantly increase the Systems Engineering modeling and analytic capabilities of the students.

The Capstone team will also be supported by Major Marcus Grimes, Systems Engineering M.S. student.

Horowitz Barry M. and Haimes Yacov Y. Risk-Based Methodology for Scenario Tracking, Intelligence Gathering, and Analysis for Countering Terrorism, 2003
2009-16  **A Risk-Based Approach to Protecting Accessibility, Mobility, and Safety Options for Transportation Corridors**

**Client:** Virginia Department of Transportation and various Virginia regions and localities

**Faculty Advisor:** James H. Lambert

**ITAR/Citizenship Restriction?** [Yes/No] No

**Project Description**

VDOT is increasingly involved with the land development process in rapidly evolving transportation corridors. The land development process on transportation corridors includes rezoning, points of interest, real estate, public utilities, right of way, access management, and the transportation facilities themselves. Localities, which are competing with one another for economic development, may be slow to share their plans for developing corridors, or they may not be aware of impending development. It is therefore important that VDOT transportation planners anticipate and address future development along corridors and avoid surprise, regret, and belated action. This project proposes to develop a comprehensive risk-based approach to identifying and prioritizing needs for corridor protection strategies on undeveloped roads.

The *purpose of this Phase 2 effort is to provide training and implementation* of the Phase 1 methodology that supports the identification, prioritization, and protection of transportation corridor sections that could face significant land development in five to ten years. The effort will be conducted in close partnership with VDOT Transportation and Mobility Planning Division, the RRRC, and Virginia localities.

The project is a continuation of a Masters Thesis and a previous capstone project. Team members will work on refining the risk-based methodology as well as creating and providing training in the methodology for Virginia regions and localities. Team members will gain experience in basic GIS experience, consulting, technology transfer, and oral presentation. Ability to learn quickly and develop and present relevant material for both executive and technical audiences is recommended.
RISK-BASED DECISION ANALYSIS FOR AN AFGHANISTAN SUSTAINABLE INFRASTRUCTURE PLAN

Client: US Army Corps of Engineers and US Agency for International Development

Faculty Advisor: James H. Lambert

ITAR/Citizenship Restriction? [Yes/No] No

Project Description

The Afghanistan Sustainable Infrastructure Plan (ASIP) is concerned with rebuilding the war-torn country of Afghanistan through projects involving infrastructure, utility services, and government and economic structuring. With limited resources, the US Army Corps of Engineers needs to prioritize among projects to maximize the return for US and Afghan investments. For project prioritization, multi-criteria decision modeling will be used to try to come up with both a set of projects to be initiated and the schedule and critical path on which these projects will be implemented. The criteria used for project selection will be based on the US Department of Defense program Measuring Progress In Conflict Environments (MPICE). With the uncertainties with Afghanistan’s future security, economics, politics, etc., we will attempt incorporate a variety of risk scenarios into the decision making process.
A program manager faces a continuous series of allocation tasks. At any given time he or she must allocate limited resources, funds and personnel, to an array of inter-related tasks. The allocation must be made in the face of considerable uncertainty about the actual resource requirements of a task and the impact of task completion on the achievement of overall goals. While there is an extensive literature on analytical methods for program management, the practice is far more heuristic. A significant impediment is that program managers have only limited opportunities to learn. For the more complex programs, those lasting five to ten years, a program manager may only be fully in charge once. Even when the manager has previously served as a deputy and in other roles, he or she is unlikely to have had more than two or three opportunities to see a program lifecycle. Today, as teams become highly distributed, the manager may never have seen a program through end-to-end.

One possible approach to more effective development of experience is through gaming. This project seeks a proof-of-concept for a “serious game” that represents the decision problems faced by a program manager of a complex, technical development program. Today, nobody really knows whether or not gaming concepts can be usefully applied to this problem. The goal of this project is to produce several prototype program management games representing different aspects of management learning.

The intent of this project is to produce several prototype games that illustrate different aspects of the program management problem. Some of the aspects of interest include:

1. Resource allocation in well defined, but complex, management situations. The basic example is allocating resources in many-task project plan with uncertainty about effort-to-complete.
2. The impact of different overall structuring decisions on program outcomes. For example, structuring a program for incremental delivery versus all-at-once.
3. Interaction with stakeholders with different preferences, some of whom may be able to kill or otherwise effect the program.
4. Synergistic experimentation with analytical management tools. Giving the program manager an opportunity to compare strategies from analyses with those developed by intuition.
5. Presentation to the learning program manager the consequences of longer-term, synergistic or antagonistic interactions. For example, illustrating the impact on last phase integration of poor early phase development, or the effect on ultimate cost of production from budget ceiling driven program stretchouts.

See the work on “Tanaland” in the book “The Logic of Failure” by Dietrich Dorner and similar work by the book’s author (additionally, see an old example of optimal and non-optimal loading of development tasks is discussed in Chapter 17 of “Controlling Software Projects” by DeMarco)
EMULATION AND ANALYSIS OF A SATELLITE NETWORK INFORMATION MANAGEMENT AND DISTRIBUTION SYSTEM

Client: U. S. Department of Defense

Faculty Advisor: Gerard P. Learmonth Sr.

ITAR/Citizenship Restriction? [Yes/No] No

Project Description:

Last year, a capstone project performed an initial investigation of the design and development of an integrated system to model and analyze the performance of a low-earth orbit (LEO) satellite constellation. The distributed satellite network deploys a diverse set of services (e.g., imagery, classification, tracking) using the Service Oriented Architecture (SOA). One of the distinguishing characteristics of this distributed satellite network is that computing and data management are to be performed in space, that is, onboard the satellites themselves with its attendant challenges.

The network of satellites will collect data via various sensors; perform a set of processing tasks (services) upon the collected data and previously stored data; and present the results to a variety of heterogeneous users. Given the choices of satellite network architecture; communication latencies inherent over great distances between and among satellites and other assets; the coordination required among cooperating satellites in the delivery of services; and the amount of processing required to complete a given service task, questions of overall system performance are to be addressed.

Last year’s capstone project integrated a software emulation component, the STK (Satellite ToolKit) package, and the Google Earth service into a working model. The emulation component allows workstations to mimic the functionality of individual satellites including their processing activities and communications. STK – a commercial application – provides the satellite orbital and performance characteristics, radio communications characteristics, and inter-satellite message routing. Google Earth provides an out-of-the-box method to simulate an imagery service.

This year’s capstone project will significantly extend and enhance the existing emulation model. Among the extensions envisioned are to explore different satellite configurations, including the addition and deletion of satellites; the integration of different services, for example, classification and tracking services; and examining different routing protocols. The project will require members of the team to either know or learn a number of technical elements including familiarity with the C# programming language (the emulator is written in C#); the STK package; communications methods (principles of message routing); and Service Oriented Architecture design principles.

This project involves all the elements of good systems engineering – design, analysis, and technical integration.
2009-20

IMPROVING ACCESS TO SAFE WATER, SANITATION AND COMMUNITY HEALTH IN LIMPOPO, SOUTH AFRICA.

Client: The Center for Water, Health, Environment, and Development (WHEAD)

Faculty Advisors: G. E. Louis, R. Dillingham

ITAR/Citizenship Restriction? No

Project Description
There are 1.2 billion people that lack access to clean water for drinking and personal hygiene, and 2.4 billion that lack access to basic sanitation for defecation and other human waste. This situation contributes to elevated rates of mortality and morbidity among the affected populations, including the deaths of 1.8 million people annually (WHO, 2004) most of whom are children under 5 years of age. The situation is worst in Africa, Asia, and Latin America and the Caribbean. Asia has the largest number of people without access to water and sanitation services (WASAN), and Africa has the highest percentage of population lacking access. The Center for Water, Health, Environment, and Development (WHEAD) is a dedicated group of faculty members and students at the University of Virginia (UVA) and University of Venda (UNIVEN) conducting research on building local capacity to provide access to safe water and sanitation services, and improve human health outcomes in developing communities, with a special emphasis on Africa. Permanently solving the problems of inadequate access to WASAN services and adverse human health outcomes in developing communities will require ownership and management of the problem and its solution by each community with its own resources. WHEAD is establishing a model for building that capacity in the Limpopo province of South Africa, where the UVA has an ongoing strong partnership in wasan and health interventions with UNIVEN.

The goal of the project in Limpopo is to build local capacity for sustained access to safe water and sanitation services, and for minimizing adverse health outcomes from wasan-related diseases throughout the Limpopo region. The goal of the Limpopo Capstone is to create a detailed requirements document for implementing the Limpopo project. This will be achieved through 5 objectives:

1. Define the project goals and objectives.
2. Develop indices of performance for evaluating achievement of the project objectives.
3. Define the key project stakeholders, their roles, interactions with other stakeholders, and process document for managing these interactions
4. Develop a master work plan for the project identifying the main project activities, stakeholder activities, schedule and significant milestones.
5. Develop and implement a web-based tool for collaborative management of the project by stakeholders at the University of Virginia, and the University of Venda.

The Capstone group will meet once each week with the project advisors at the University of Virginia, and submit a weekly project report each week to the advisors at UVA and University of Venda (UNIVEN). At least once each month the Capstone team will participate in a conference call between the project members from UVA and UNIVEN, providing all relevant supplementary documents for such meetings via the project website. The Capstone team will provide a detailed project work plan and all required academic publications as the main products of this project.

Note: There are several other faculty involved from other schools who have not had a chance to edit this description as yet: so the text is likely to change a bit. However, this conveys the main aspects of the project and is enough for students to use in making their selection.
Electronic Medical Records (EMR) are emerging as a key tool for streamlining patient care in the United States and abroad. EMR has the potential to significantly enhance the continuity of patient health information, so that, even when patients change healthcare providers, doctors can quickly and accurately assess patient history. In addition, EMR systems have to potential to integrate with insurance companies, health systems, and Medicaid/Medicare, potentially reducing administrative costs associated with reimbursement for lab tests, diagnostics, pharmaceuticals, and other medical interventions.

Interoperability is a key issue for EMR systems. Data formats and codes are currently being standardized, so that the EMR maintained by one health care provider on behalf of a patient can be transferred to a new provider when the patient switches providers. However, the business model for interoperability is not so clear. Vendors of “enterprise” EMR systems, with interface software and databases that can be installed for institutions (clinics, hospitals, health care providers), may seek to limit interoperability as a strategy for securing market-share. Vendors of “personalized” EMR systems (such as Google Health), which emphasize the individual patient’s role in maintaining health records, also face pressure to differentiate their products perhaps at the expense of some interoperability. Clearly, there are many issues relating to ownership of health data and privacy, and governmental regulation of this industry is taking shape.

This capstone project, sponsored by the NSF, seeks to contribute to the dialogue about emerging EMR systems through a number of distinct research and development activities:

1. Conduct a survey of existing and emerging EMR/EHR software packages and services
   a. Compare and contrast systems developed under the “enterprise” and “personalized” models of patient interaction with EMR systems
   b. Evaluate and characterize process improvements associated with EMR from the perspectives of different stakeholders, including patients, physicians, clinics, health systems, and national health infrastructure

2. Recognizing that demographics can significantly affect the decision to adopt EMR, develop an agent-based simulation model that can shed light on how EMR systems would be utilized in the different types of communities:
   a. Metropolitan regions (e.g., NOVA)
   b. Affluent rural regions (e.g., Southwest VA)
   c. Developing countries (e.g., South Africa)

3. Testbed prototype and experimental evaluation of best-practices architecture and design for EMR in developing countries.

4. Prototype implementation and experimental validation will be a major part of the capstone group’s activities. While programming is not a central focus of the project, the work will necessarily involve some high-level software development; a willingness to develop this skill is expected.
Quoting Timothy P. Carney, National Review Online 6/26/06: 

Agency chiefs and Cabinet secretaries usually try to be discreet about their jealousies, resentments, and grudges towards other departments and agencies in the federal government. On Friday, however, Homeland Security Secretary Michael Chertoff was upfront about his agency-envy, declaring in front of a packed house C-SPAN cameras how he wished his agency had the same technologies that the Counterterrorism Unit has in the Fox television series 24. "I wish we could have instant communications. I wish we didn't have systems that sometimes went down and broke." In 24, Chloe O'Brian can instantly access real-time feeds from satellites with infra-red technology and stream the images to Jack Bauer's PDA so he can know exactly where the bad guys are...

Besides Jack Bauer, there are many mobile field users -- such as soldiers, emergency responders, and security personal -- who would benefit from receiving customized up-to-the-minute intelligence imagery. As Secretary Chertoff points out, however, such imaging services are normally delivered over high-capacity infrastructure to hardware-rich users. To make these services available to processor and bandwidth-impoverished mobile users the processing and networking requirements of the services must be greatly reduced.

Over the last several years, students and faculty of the Wireless Internet Center for Advanced Technology (WICAT) at the University of Virginia have developed a prototype system known as the Mobile Information Processing Architecture (Mobile IPA) System, in which cameras feed images to mobile end users over a highly flexible network architecture. In the Mobile IPA System, a foreground-background separation algorithm is used to detect and isolate the images of objects intruding on the scene. Only the foreground images (changing regions) are transmitted, which results in a savings of network bandwidth and end user processing. A related 2007/08 Capstone project addressed the complex issues that arise when a diverse population of mobile users utilizes a common set of sensing, processing, and communication resources in a Mobile IPA System. The team developed and successfully demonstrated (1) a scheme for quantifying and updating user preferences and (2) algorithms that reconcile the diverse interested of mobile users with limited resources including bandwidth and processing capacity.

This project will focus on developing and evaluating a PDA client application for the system above, focusing on (1) cognitive issues associated with the user interface and (2) performance of the system in terms of its ability to deliver the right information at the right time to the user population as a whole. Prototype implementation, live demonstrations of technology, and experimental validation will be a major part of the capstone group’s activities. While programming is not a central focus of the project, the work will necessarily involve some JAVA coding; a willingness to develop this skill is expected.
EXPERIMENTAL DESIGN FOR ARES I STATIC TESTS

Client: NASA Langley Research Center (LaRC)/National Institute of Aeronautics (NIA)

Faculty Advisor: K. Preston White, Jr., Professor

ITAR/Citizenship Restriction? Yes (rank this at the bottom if not a US citizen)

Project Description

Background. NASA’s Constellation Program is destined to send human explorers back to the moon, then onward to Mars and other destinations in the solar system. Crew transportation to the International Space Station is planned to begin no later than 2014. The first lunar excursion is scheduled for the 2020 timeframe [http://www.nasa.gov/mission_pages/constellation/main/index.html].

NASA already is at work developing hardware and systems for Constellation’s new Ares I rocket. In addition to the vehicle’s primary mission -- carrying crews of four to six astronauts to Earth orbit -- Ares I may also use its 25-ton payload capacity to deliver resources and supplies to the International Space Station, or to "park" payloads in orbit for retrieval by other spacecraft bound for the moon or other destinations.

Ares I is an in-line, two-stage rocket configuration topped by the Orion crew vehicle and its launch abort system. During launch, the first-stage booster powers the vehicle toward low Earth orbit. In mid-flight, the reusable booster separates and the upper stage's J-2X engine ignites, putting the vehicle into a circular orbit.

Our project. In support of Ares I, static testing of full-scale reusable solid rocket motors is performed. From the static firing data, requirements are verified and the motor’s performance is characterized for guidance, navigation, and control simulation.

One of the parameters of interest is dynamic thrust vector misalignment (DTVM)—the difference between the nozzle vector angle estimated from (i) the force measurement system (vector resolution) and (ii) a position-sensing system (measured location). From static firing measurements, we need to verify that a stated percentage of all motors have a DTVM less than an experimentally estimated value with a specified level of confidence. DTVM is a function of a range of factors and the requirement applies to the family (population) of motors. Therefore, DTVM is not a single number; rather it is expressed as a mathematical response surface model.

This task requires the development and evaluation of statistical design of experiments approaches to verify probabilistic requirements. The technical support needed requires statistical and probabilistic consulting (problem definition and solution approach formulation), analysis, interpretation, and communication of approaches and results.

Work to be Performed. As a team, we will

- Define the problem from a systems engineering perspective and clearly identify the statistical and probabilistic challenges.
• Perform a literature search on statistical experimental design to verify probabilistic requirements. In particular, identify current literature and standards on the probabilistic requirements for simulation studies.
• Provide a systematic approach to this class of problems.
• Perform simulation of experimental results that enable sensitivity studies to give practical insights into the relationships between the experimental design parameters, the number of statistic test required, and the probabilistic requirement values.
• Recommended approaches to verify the probabilistic requirements and demonstrate their derivation and application to Ares I DTVM.
2009-24  GPS TRACKING OF INTERMODAL TRANSPORTATION: SYSTEM INTEGRATION WITH DELIVERY ORDER SYSTEM

Client: TMO Global Logistics, LLC.

Faculty Advisor: Michael Smith and Jianping Wang

ITAR/Citizenship Restriction? [Yes/No] No

Project Description

One of the emerging trends in the transportation industry is the use of GPS devices to track the movement of cargo on a global scale. Currently TMO Global Logistics, LLC. uses an order entry / tracking system which takes manual input of data as to the tracking of cargo along the supply chain. We would like to have UVA Systems Engineering students, along with Computer Science students, research and develop a system which integrates GPS tracking into the current order tracking software.

There are a couple ways that we see this being displayed. The first and our preference would be on a mapping system such as Microsoft Map Point. The second would be to develop a system which gives distances to and from the pick-up and drop off locations around the globe. We are open to other possibilities if the Students have any better ideas.

Due to the critical nature of this project to TMO's competitive position, students on this project must agree to transfer all intellectual property rights to TMO.
2009-25  Trauma Registry Database Front End/Clinic Note Generator

Client: University of Va Health System - Department of Surgery

Faculty Advisor: Stephanie Guerlain, SIE and J. Forrest Calland, Surgery

ITAR/Citizenship Restriction? [Yes/No] No

Project Description

Before a severely injured patient ever arrives for care in the regional university-based Level I Trauma Center, the process of data collection has already begun. Clinical data for injured patients are simultaneously collected by hundreds of individuals within the healthcare delivery system and deposited in multiple disparate data repositories. Such data remains uninformative until the trauma registrar begins the onerous and time-consuming process of reassembling such data into useful chunks that can populate the central database, or Trauma Registry. Unfortunately, critical data points are either missing, inaccurate, or unavailable when the time comes to create the permanent record, thus limiting the future utility of such data for assessing/determining the safety and quality of the care. Several trauma centers of national prominence have sought to close this accuracy gap in the trauma registry by hiring advanced clinicians as data abstractors for the sole purpose of improving the accuracy of such data. Using advanced clinicians in this way is an expensive and inefficient use of individuals whose time and expertise is already in high demand.

Though physicians are writing daily notes and assembling data from the multiple data sources to make clinical judgments, there is no way to efficiently transfer such data into the registry to close the aforementioned accuracy gap. Thus, the opportunity exists to formulate a system whereby the data from a clinician’s note would auto-populate the trauma registry, thereby freeing-up the redundant and valuable human-resources that are also attempting to assemble the data. If the trauma registry was populated with accurate and timely data, it would simultaneously create a robust data set with utility for advanced assessment of care quality, resource utilization, and risk-adjusted assessment of outcomes.

One potential solution would be to create a front-end GUI for the trauma registry that would serve the dual purpose of creating the clinical note for physician documentation and population of the registry. Creation of such an interface would save an organization considerable money and free up personnel for activities that generate revenue or enhance patient outcomes. Simultaneously, such an effort would yield an efficient and accurate process for creating a robust permanent dataset for post-hoc analysis.

Desired Skills: This project is good for those who enjoy requirements analysis, designing software user interfaces and/or database design and/or who are interested in going to medical school or working in the medical informatics field. Students should have done well in and enjoyed SYS 202 and SYS 323. Please don't hesitate to contact Prof. Guerlain for more information to discuss if this would be a good project for you.
2009-26  US-BRAZIL RIO DE JANEIRO TEAM

Client: BR

Faculty Advisor: Stephanie Guerlain

ITAR/Citizenship Restriction? No

Project Description
This is a project that started last year, students have already applied for this project and are currently in Brazil. No additional students will be added to this team.

2009-27  US-BRAZIL PORTO ALEGRE TEAM

Client: Santa Casa Hospital

Faculty Advisor: Ellen Bass

ITAR/Citizenship Restriction? No

Project Description This is a project that started last year, students have already applied for this project and are currently in Brazil. No additional students will be added to this team.