PRESENTATION ABSTRACTS

STEM AIAD Hampton, Virginia Experience

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We started our trip in Washington DC and learned about the United States Department of Housing and Urban Development (HUD). While we were here we learned about the support that HUD provides to underprivileged communities. We focused more on the help that they provide teaching the children of these communities about the importance of pursuing STEM careers. After this we went to Hampton, Virginia and learned more about the work that this specific city was doing for its lower income communities, we were able to meet with the city leadership and hear about the programs that they are implementing. We also got to witness a ceremony where the navy was building houses for lower income families that qualified and watched a family move into these new houses. The most impacting part of this trip was going to the boys and girls clubs and visiting with the kids and letting them know how important math and science fields are and why STEM is so important. We also answered any questions they had about high school, college, the military, and life in general. Seeing those kids get more and more interested in what we were talking about to the point where they didn't want us to leave in the end was so inspiring. The last thing we did while we were in Hampton was the STEM workshop. We taught the kids how to build and program robots and at the end they had a competition with who programmed the robots the best. They were so happy to all receive their certificates and loved building the robots, this was also an extremely inspiring experience. The last thing that we did on this AIAD was visit the Army Research Labs (ARL) and learn about the different things they are working on for the army. We got to tour two of the labs and see the different types of rooms they had and the different types of work that they do. All in all this was an extremely educational trip and has definitely helped us decide what we want to do if/when we get out of the army.

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Human-on-a-Chip

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The approach to migrate from 2D cancer and animal derived cell culture to 3D human stem cell derived organotypic models that stimulate the physiological response of organs and organ systems is presented. The individual organoids (heart, liver, lung, and vasculature) will be maintained in separate chambers on a chip that are subsequently linked via microfluidics. The microfluidics device will be stored in a temperature controlled incubator that is attached to an automated valve controller, electrochemical station, and physical/chemical sensors. The human-on-a-chip system will provide analysis of chemical threat agents for human toxicity and potential medical countermeasures.

KEYWORDS: Organotypic, Organoids, Microfluidics, Chemical Threat Agents

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Measuring Communities and Networks of Network Scientists

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During a summer Internship with the Army Research Office, we explored the inner networks of the Army-funded and Army-employed researchers within the Army's research program entitled Network Science – Collaborative Technology Alliance (NS-CTA). We analyzed the influence and presence of the researchers in the NS-CTA over the span of several years. The purpose of our research was to understand and measure the Army's development of this large community of university and government researchers to provide insights on how to enhance this process and better manage cohesive communities of network scientists.

KEYWORDS: Network Science, Research Community, Coauthors, Big Science

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Tomorrow's Science Connections: Networks, Measures, Motivations

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Scientific research may traditionally be an evolutionary process, but currently there is such an abundance of rapid and dramatic changes taking place that it seems to be revolutionary. This revolutionary fervor of modern science is creating a paradigm shift in the methodology (structure and process) of science. Elements of this shift include moving from little science (single investigators) to big science (multi-disciplinary teams of scientists), the increased role and acceptance of complexity, recognition of the informational and networked nature of science, and the utilization of science within the human context of society. In addition to presenting a framework for tomorrow's science from the work of Bruce West that includes these elements, we present an anecdotal, but interesting and compelling, exemplar of some of these changes. This structural and process-based example compares the two degrees of separation network of László Barabási's coauthors (circa 1995-2015) with the same kind of coauthor network of famous mathematician Paul Erdős (circa 1935-1995). The dramatic differences in these two networks indicate significant and dramatic change is taking place in the world of scientific research.

KEYWORDS: Big Science, Research Community, Coauthors, Network Science, Tomorrow's Science

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A Static Bernoulli Random-graph Model for the Analysis of Covert Networks

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A static Bernoulli random-graph model is presented as a way to account for edge uncertainty when analyzing insurgent networks. The results of this work demonstrate that stochastically generating thousands of network structures, where known associations are held constant and suspected associations are treated as independent random variables, has the effect of proportionally emphasizing corroborated information from reliable sources. Evaluating multiple structures also enables an analyst to quantify the certainty of centrality-based targeting recommendations and lessens the implications of subjectively including or omitting specific pieces of information.

KEYWORDS: Bernoulli random-graph, dark network, covert network

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Comparing the Prediction Capabilities of an Artificial Neural Network vs a Phenomenological Model for Predicting the Terminal Ballistics of Kinetic Energy Projectiles

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The need to accurately predict the terminal ballistics of kinetic energy projectiles in Vulnerability/Lethality models is of paramount importance the Department of Defense. An artificial neural network was trained on a set of 1,625 data points to predict perforation, residual velocity, and residual mass of a kinetic energy projectile impacting a homogeneous-monolithic-metallic target. The capability of that neural network is analyzed against a phenomenological model that is currently used by the Department of Defense for modeling the terminal ballistics of kinetic energy projectiles. Results show that the neural network model is superior in speed and accuracy to the current phenomenological model.

KEYWORDS: Artificial Neural Network, Kinetic Energy Projectiles, Terminal Ballistics.

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AIAD: The Housing and Urban Development / Army Research Lab MD

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The United States Military Academy and the United States Army plays a crucial role amongst many distinct and important organizations that exist across the nation. The public and human services that are provided by the Housing and Urban Development, located in Washington D.C., highlights the community issues that our nation has at the lower level. Meanwhile, these programs also address what we as organizations can do to serve the people and their communities. Many communities, especially one that we visited in Richmond VA, need the resources and assistance that can only be provided sufficiently with the help from diverse organizations. The Army Research Lab, located in Maryland, is a coalition with diverse individuals, including students, civilian contractors, soldiers, and many scientists and engineers. By combining these powerful resources, the men and women of America will be more able to serve not only their communities' needs, but also the nation as a whole.

KEYWORDS: The Housing and Urban Development (HUD); Army Research Lab (ARL).

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Hierarchical Assembly of Bio-Templated Nano-wire and Nano-tube Films for Lightweight Multi-functional Materials

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Biological hydrogels can serve as 3-dimensional bio-templates for tunable nano-porous materials that serve both as electrochemical power sources and structural material. We present a general approach to 1) form a biological hydrogel; 2) sensitize the hydrogel bio-template using catalytic palladium ions to mediate the electroless deposition; 3) synthesize 3-dimensional networks of copper and nickel nano-wire films via electroless deposition; 4) synthesize inorganic salt templated square cross-section nano-tubes that can be integrated into a hierarchal nano-material assembly. Such multi-functional electro-mechanical materials are envisioned to decrease the systems mass across a broad range of Army platforms and serve as a nano-architecture for other applications such as photovoltaics, catalytic systems, sensors, and energy absorption.

KEYWORDS: Hydrogel, bio-templates, nano-materials, electrochemical, biotemplating

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Modeling the Impact of Attacker Skill on Platform Diversity Active Defense

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Despite the significant effort directed toward securing important cyber systems, many remain vulnerable to advanced, targeted cyber intrusion. Today, most systems which provide network services employ a fixed software stack that includes web servers, databases, an operating system, and a virtualization layer. This software mix as a whole constitutes the attack surface of the host, and a vulnerability in one or more of these services is a threat to the security of the entire system.

Moving target defense (MTD) aims to increase the security of a system against successful intrusion by increasing an attacker's uncertainty of the attack surface. Platform migration is a form of MTD that entails changing the virtualized software stack configuration of a host. We consider a scenario in which an attacker gathers information and then selects and launches an attack against a target host which is implementing a platform migration defense. We use agent-based simulation model to evaluate the MTD's effectiveness depending on the capabilities of the attacker and defender. In particular, we focus on two core characteristics of a platform migration defense: (i) change rate, the frequency of changing platforms, and (ii) platform diversity, the variety of configurations available to a host, as well as two dimensions of two major contributors to the attacker's skill: (i) reconnaissance, the ability to collect accurate information regarding the target system, and (ii) arsenal size, the number of usable payloads at the attacker's disposal. We perform simulation experiments to evaluate a defender's ability to protect itself against a spectrum of attackers ranging from "script-kiddies" to state-sponsored actors. Our results indicate that increased platform diversity results in a lower rate of successful attacks, even in cases where the attacker has near-perfect information regarding the target system. Furthermore, although the strength of an attacker is often measured by their ability to acquire a large arsenal of available exploits, preliminary results suggest that reconnaissance capabilities may be just as important determinant for the success of an attack as the arsenal size. Finally, we show that increasing the frequency of platform migration moderates the influence of reconnaissance capabilities up to a threshold, above which increasing in reconnaissance accuracy does not increase the success rate of the attacker. We discuss the relationships between migration characteristics and attacker characteristics and how understanding them can support decision making processes of cyber defenders and lay the grounds for effective automation of cyber maneuvers.

KEYWORDS: Moving target defense, platform diversity, attacker skill, modeling, reconnaissance

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Smart Camouflage Body Armor

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The Unites States Army spends large amounts of time and money every few years to develop new uniform patterns that better suit the environments in which soldiers operate. A "smart" camouflage would mitigate these expenses by allowing uniforms to change their coloring depending on where a soldier is deployed. Preliminary data was collected at the Biological Interface Lab in South Korea in conjunction with the Disease Biophysics Group at Harvard University this past summer. Silver electrode patterns were printed on para-aramid fabric, a fiber similar to Kevlar, and the homogeneity and conductivity of the printing was tested. These electrodes were utilized to heat thermochromic dyes and induce a color change. This was achieved by painting patterns of the dye onto electrodes before applying a current. The ability to control the color change in certain regions of the thermocromic patterns was experimented with and, moving forward, we will seek to gain further control as well as utilize more realistic colors for camouflage patterns.

KEYWORDS: Conductivity, Body Armor, Electrodes, Temperature, Silver Inkjet Printing, Control, Camouflage

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Evacuated Processing of UHPC to Reduce Air Entrainment

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Mixing of Ultra-High Performance Concrete (UHPC), under both ambient and slightly evacuated conditions, was performed. Under ambient conditions, large air voids are present in the material after setting, indicative of air entrainment during the mixing process. In an attempt to relieve these air voids, UHPC was mixed and placed in the mold and allowed to set under slightly evacuated conditions. Unfortunately, air voids were still present in the formed body; however, a more significant vacuum may be necessary to further validate this technique. Assessments of density and computation tomography (CT) scanning provided the basis for our conclusions. Additional testing of uniaxial pressing demonstrates water migration, reducing the viability of pressing samples as a method of reducing air voids. Further analysis of mixing UHPC under stronger vacuum conditions is recommended.

KEYWORDS: Ultra High Performance Concrete, Vacuum, Entrainment

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On families of orthogonal Laurent polynomials, hyperelliptic Lie algebras and elliptic integrals

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Date-Jimbo-Kashiwara-Miwa (*DJKM*) studied integrable systems arising from Landau-Lifshitz differential equation, which describes time evolution of magnetism in solids. *DJKM* introduced an infinite-dimensional Lie algebra, which is a one-dimensional central extension of a loop algebra of the coordinate ring of a Riemann surface with a finite number of punctures. I will describe a family of polynomials discovered through a particular recursion relation, giving us rich properties analogous to those of Chebyshev polynomials of the first and the second kind, and the polynomial version of Pell's equation. I will show that these families of polynomials satisfy certain second order linear differential equations that are of interest to mathematicians in conformal field theory and number theory. In particular, in the *DJKM*-setting, these families of polynomials are orthogonal when multiplied by a suitable power of t, and with respect to explicitly-described kernels. This is joint with Ben Cox, a faculty of mathematics at the College of Charleston.

KEYWORDS: Integrable systems, Date-Jimbo-Kashiwara-Miwa algebras, infinite-dimensional Lie algebras, Chebyshev polynomials, conformal field theory, mathematical physics, representation theory

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Numerical Modeling of Pedestrian Motion

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The accurate prediction of pedestrian motion can be used to assess the potential safety hazards and operational performance at events where many individuals are gathered. Examples of such situations are transportation hubs, sport and music events, cinemas and theatres, museums, conference centers, places of pilgrimage and worship, as well as street demonstrations. Evacuation from buildings, and even airplanes, ships or trains also represent cases where the prediction of pedestrian motion can be used advantageously.

Over the last decade, a pedestrian flow (PEDFLOW) simulation tool has been developed at GMU to numerically model the motion of pedestrians. This simulation tool has been repeatedly validated against analytical solutions and experimental measurements, some of which involved up to a thousand pedestrians.

This seminar will review the different options available to describe and predict the motion of pedestrians, detail the PEDFLOW simulation tool, highlight the utility of performing verification and validation, and demonstrate some of the experimental campaigns and simulations carried out to date.

KEYWORDS: Pedestrian Modeling, Simulation, Evacuation Modeling

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Combating Terrorism: How To Degrade A Terrorist Network By Strengthening A Us Support Network

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To combat terrorism abroad, the US Forces seek to degrade a terrorist support network and strengthen a US support network. We describe a general framework for the problem of influence maximization in a social network. Solutions identify key individuals to serve as a focus for US efforts to expand support. Our framework both captures previous work in the area and yields many novel problem formulations. We demonstrate the framework's applicability through insights gained on several examples.

KEYWORDS: terrorism, US efforts

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Optimizing Dark Network Discovery through Intelligent Walks

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Based on graph search techniques and centrality measures, algorithms were made locally intelligent by implementing a variety of conditions. The algorithms were applied across graphs of multiple topologies and varying sizes. The results of these algorithms were compared against controls. Assuming realistic conditions, walks were focused on. Graphing the percent of network discovery against nodes monitored presents an apparent network-knowledge upper bound for each given number nodes monitored. The results offer analysts options for discovery of different network topologies, and the research presents visualization tools to monitor network discovery in real time.

KEYWORDS: Graph visualization, Real-Time, Dark Networks, Discovery, Algorithm Optimization

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Technique of Determination of Spatial Distributions

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A means of evaluating the spatial or geographic dispersion of objects is presented to determine if the underlying distribution results in clumping, uniform, or random arrangements. Frequently researchers are interested in determining whether or not a population or arrangement of objects is dispersed according to an underlying theme, or whether randomness prevails. This technique utilizes metrics from network science and has applicability regarding ecological modeling and population distributions.

KEYWORDS: Network Science, Population Distributions

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A Hybrid Tactical Power Grid for Forward Operating Bases

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Forward Operating Bases require a large source of electrical power for all mission essential equipment, soldier support systems, and other personal devices. To accomplish this, many FOBs utilize a diesel-fuel burning generator; however, many of these generators are being operated at sub-optimal levels due to a lack of field expertise and system planning. This combined with the unpredictable cost of diesel-fuel and the risks associated with transportation convoys make the power supply problem of FOBs an urgent issue with a solution that is within reach. Answering this problem requires developing a system which could harness alternative energies as well as autonomous load switching to ensure that all generators are operating between 50-90% of their rated capacity. The Hybrid Tactical Power Grid achieves this in several ways: through integrating dissimilar sources such as photovoltaic panels and battery hybridization, and by combining automated and user power and load control to the system. Employing this system would guarantee a constant power supply in a more energy efficient manner. Beneficial secondary effects of this system include a smaller carbon footprint and fewer security issues due to failing generators.

KEYWORDS: Hybrid Tactical Power Grid, Forward Operating Base, Photovoltaic, Load Management, Diesel-Generator

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Utilizing Socio-Economic Factors to Evaluate Recruiting Potential for a US Army Recruiting Company

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US Army currently calculates recruiting capacity as a four year weighted average of historical data. We investigate two alternate methods for the same task -- multiple linear regression (MLR) and Poisson regression (PR). Regression methods can account for the impact of economic factors on recruiting capacity, whereas weighted average methods do not. Surprisingly, we show that MLR models provide better fits than PR models, even though existing literature largely focuses on PR models.

KEYWORDS: Poisson regression, MLR models

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What Happens When You Lock Systems Engineers and Modeling & Simulation Practitioners in a Room?

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The West Point Department of Systems Engineering and the US Army Research Laboratory Human Research and Engineering Directorate Simulation and Training Technology Center Advanced Simulation Branch have a long history of collaboration on research efforts aimed at applying Systems Engineering (SE) processes and methods to Modeling and Simulation (M&S). This presentation will discuss three research efforts that demonstrate the benefits of this collaboration while highlighting some of the key findings that have furthered the state-of-the-art. First, we will discuss the Executable Architecture Systems Engineering (EASE) research project, which aims to link high-level analytical requirements with modeling and simulation system execution details through an automated data-driven system to greatly reduce the set-up and execution time of complex, distributed simulation environments. Then, we will discuss the Distributed Soldier Representation (DSR) research project, which aims to provide a Soldier-focused, service-oriented, distributed modeling and simulation architecture that leverages models of cognition, morale, Soldier resilience, human physiology and psychology, unit cohesion, effects of stress, unit as a complex adaptive system, leadership, decision science and the effects of the Soldier as a family member. Finally, we will discuss the Distributed Modeling Framework (DMF) research project, which explores the integration of models through a functional programming paradigm vice how simulations are usually built and interoperated.

KEYWORDS: Systems Engineering, Executable Architectures, Modeling and Simulation, Soldier Modeling

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Harmonic Vibrational Frequencies: Approximate Global Scaling Factors for the TPSS, M06, M08, and M11 functional families using common basis sets

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We are attempting to calculate approximate global multiplicative scaling factors for the Density Functional Theory (DFT) calculation of harmonic vibrational frequencies using both meta-GGA and meta-Hybrid functionals from the TPSS, M06, M08 and M11 families. Standard Dunning Correlation Consistent, Pople split valence, Sadlej, and Sapparro polarized triple-ζ basis sets are employed. A total of 96 harmonic frequencies are being calculated for 30 gas phase organic and non-organic molecules typically found in detonated solid propellant residue. Our proposed approximate multiplicative scaling factors are determined using a least squares approach comparing the computed harmonic frequencies to experimental counterparts well established in the scientific literature. A comparison of our work to previously published, well established, global scaling factors will be made to test the reliability of our methods and molecular test set. The status of this project will be presented at the meeting.

KEYWORDS: Density Functional Theory, DFT, Harmonic Vibrational Frequency, Scaling Factors

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Axon-Sorting Multifunctional Nerve Guide:
Giving Prosthetics the Sense of Touch (SENSA Project)

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The goal of the SENSA project is to create a multifunctional nerve guide that can confer sensation to prosthetics. We propose to develop an implantable guide which functionally sorts the regeneration of extending nerves along independent branches: one motor and one sensory. Conferring sensation is entirely possible to achieve, but requires physical separation of sensory axons from motor axons at distal sites of amputation. For this project, we have focused on two areas—1) neuronal growth and guidance and 2) functional scaffold development. For the first area of study, in order to assess control of neuronal growth, we performed growth cone turning assays using dorsal root ganglion (DRG) neurons isolated from embryonic day 7 (E7) chickens. These assays were performed using 7 μm polystyrene beads coupled to trophic factors, such as nerve growth factor (β-NGF). We further characterize these neurons using western blot to assess the activation of relevant downstream signaling pathways in response to trophic factors. For the second area of study, we developed fiber scaffolds composed of 25-50 aligned type I collagen fibers each measuring 20 μm in diameter and spanning 2 cm in length. Prior to *in vitro* evaluation, we sutured and glued nerve guides to culture dishes where they were cross-linked with genipin to limit swelling. E7 DRG or motor neuron explants were seeded at one end of the scaffold and allowed to grow in culture for 2 weeks prior to fixation and imaging. Confocal microscopy revealed axon growth in 3-dimensions along and in-between single fibers, demonstrating a high degree of biocompatibility. Scanning electron microscopy revealed contact-guided growth along the fibers whereby axons spanned up to 1.7 cm in length, yielding an average growth rate of 1.2 mm/day. Most recently, bifurcated conduits consisting of two independent fiber scaffold arrays were assembled into a Y-shaped guide and evaluated in tissue culture. Following evaluation of non-functionalized guides, we plan to evaluate the sorting ability of recombinant β-NGF linked to a single branch.

KEYWORDS: neurotrophin, axon growth, fiber scaffold, regeneration, prosthetic

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INVESTIGATING THE EFFECTS OF RELATIVE HIP AND SHOULDER LOADS ON GAIT AND METABOLIC COST

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Soldiers carry heavy loads on the shoulders and hips when moving to and from mission objectives. The load contains mission essential equipment however has detrimental effects on the biomechanical efficiency of the soldier. This work investigates how such loads effect a Soldier's efficiency and ways to mitigate negative affects through ruck sack (MOLLE) weight distribution. Gait and metabolic analysis were used to compare the efficiency of the Soldier with different weight distributions between the hips and shoulders. Gait analysis was measured with a force impact treadmill and motion capture system that calculated the force distribution of the body, and metabolic cost was measured with a VO2 mask that calculated energy expenditure. Research was not completed due to time constraints, but understand of the methods of conducting, collecting, and analyzing gait and metabolic data were gathered to allow further research of gait and metabolic analysis of the Warrior Web Suit at the United States Military Academy.

KEYWORDS: Gait Analysis, Metabolic Cost, Weight Distribution, Motion Capture, Energy Expenditure

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A Modular Low-Power Cube Satellite Attitude Control System Using Magnetorquers

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In this work, we create a modular control system with magnetorquers that provides single-axis attitude and stability and control for a variety of common CubeSat configurations. We achieve this by analyzing the advantages and limitations of magnetorquers for attitude control, simplifying the controller design challenge, determining a low-power control algorithm, and testing the control solution through simulation. In a system that relies solely on magnetorquers for stability and control, the Earth's magnetic field provides the only stable frame of reference, therefore we are able to take a multi-dimensional control problem that would normally involve greater processing power and reduce it to a simple, one-dimensional control system. Taking also into account a limited power budget, we are able to design a rate-based combinational logic controller that provides attitude control on limited power and static stability with extremely little power. We validate the system with tests for standard attitude commands under different satellite inertial configurations, impulse disturbance torques, constant disturbance torques, and tumble recovery.

KEYWORDS: cube satellites, digital control systems, magnetorquers, attitude control, combinational logic control

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Understanding the Neural Integration of Multisensory Events

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As part of our investigation into how the brain binds inputs from multiple senses, 30 study participants viewed a series of movie clips while 128-channel EEG data was recorded. The two-second movie clips portrayed impact events using everyday objects (e.g., pencil tapping, ice dropped in glass, etc). The movies were altered such that in some movies the audio stimulus did not match the visual stimulus (e.g., see pencil tapping and hear ice dropped in glass). Additionally some movies intentionally lacked temporal alignment of the auditory and visual stimuli such that either the audio or visual stimulus came first by 500ms. We performed a series of pairwise trial condition comparisons to identify when different types of mismatched audiovisual stimuli become distinguishable in a subject's reconstructed brain regions. Using statistical classification methods, we look for differences in detection of an audiovisual event versus binding cues to integrate multisensory inputs. We explored the time course over which trial conditions become distinguishable as well as the variable amount of brain regions required to distinguish different trial conditions.

KEYWORDS: Multisensory Integration, Electroencephalography, Classification

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Simulation-Based Design of Devices to Augment Human Movement

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Musculoskeletal dynamic simulation can aid the design of devices that augment human movement. These devices can be used for rehabilitation or for enhancing athletic performance; in the latter role the device relieves some of the metabolic work done by muscles acting over a joint. The design of powered devices requires knowledge of the speed and torque at the joint over time. In-vivo measurement of these quantities is inherently difficult, but they can be predicted by simulation. The objective of this study is to intelligently design wearable robotic devices, including selection of motors, springs, etc.

Exoskeleton systems that transmit force to the human body have been developed for rehabilitation, for load carrying, and for enhancing strength and endurance. The simulation-based design method described in this paper is applied to a prototype hip actuator, the purpose of which is to help a person run fast. The device is light, of few parts, and is capable of delivering a significant fraction of hip power. Hamner et al. and Dorn describe simulations of human running. The author has not found any physics-based musculoskeletal simulations of humans with exoskeletons in the literature.

This study demonstrates simulation-based selection of springs and electric motors for a hip actuator to assist running. The author's vision is to utilize external power to enable an average runner to maintain his or her sprint pace for a mile.

KEYWORDS: biomechanics, exoskeleton, simulation, human performance, musculoskeletal, dynamic

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A Generic Ground-based Self-Righting Case-Study: Packbot®

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Robots operating in field environments face dynamic, uncertain conditions that can cause many platforms to tip over inadvertently. Once overturned, it can be very challenging for even a skilled operator to return the robot to its proper operating orientation without line of sight. Previously, we presented a framework for autonomously self-righting a generic robot on planar ground when possible using its existing morphology. In this work, we demonstrate how that framework can be applied to a robot designed for real-world operation: the 510 Packbot® with Camera Arm (CAM) and Small Arm Manipulator (SAM) payloads. We begin by reviewing the basic principles of the generic framework. We then describe the robot model and interface. Next, we provide the results of our self-righting analysis, including the robot's conformation space map for the shoulder and elbow, and a nodal analysis including its directed graph. An analysis of limitations was also conducted, and may be obtained by contacting the authors. Finally, path plans are shown for example starting states, and were executed by the physical hardware when possible.

KEYWORDS: Self-righting, robot, Packbot

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Inferring Pairwise Influence from Encrypted Communication

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Inferring influence between entities from observed communication activity is an important task in contexts such as intelligence and cybersecurity. Most existing approaches rely on content or meta-data, rendering those approaches ineffective when such information is unavailable, for example due to encrypted communication. In contrast, we present an efficient algorithm to infer influence between entities that relies only on the times of their individual activity, paying particular attention to the computational challenges posed by large, high-volume networks. We provide theoretical bounds on the accuracy and runtime of our algorithm relative to characteristics of network structure and dynamics, along with experiments to support our theoretical analysis and validate the effectiveness of our approach.

KEYWORDS: network, influence, inference, stochastic model, Expectation-Maximization algorithm

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Micro-scale sand particles within the hot-section of a gas turbine engine

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Traditionally, foreign object damage (FOD) has been the primary concern in aviation gas turbine engines. Current state-of-the-art particle separators can remove most of the larger sized particles (greater than ~80 μm) from the inbound air. This, in concert with high-quality, erosion-resistant coatings on the compressor sections, has significantly reduced the risk from FOD. However, smaller particles (consisting of ash, soot, dust, and/or sand) can still pass through the engine. This is especially problematic in the hot-section, where the operating temperatures of modern gas turbine engines typically surpass the melting point of many of these contaminants. The resulting impact, adhesion, melt infiltration and/or glassy solidification of these small particles can significantly damage the hot-section components within the gas turbine engine.
Empirical studies have led to a qualitative understanding/description of the resulting damage to the combustor plates and first-stage turbine blades. Yet, a quantitative understanding of the underpinning physico-chemical processes is still lacking. Solving this problem is a complex undertaking, which will involve modeling and experimentation of phenomena at multiple length scales. As part of this effort, finite element codes will determine the relevant temperatures and resulting phase state (fully or partially molten) of the contaminant particles traveling in the hot gases within the combustor and high-pressure turbine sections.

KEYWORDS: sand, gas turbine engine, thermal effects, mechanical effects

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The Engineering of Biosensors Using Fluorescent Sensor-Reporter Systems in Bacteria

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Bacteria are single-cellular organisms capable of survival under a wide variety of environmental and chemical conditions. Often, they employ communication and chemical warfare tactics to compete for scarce resources. And importantly, many species of bacteria take steps to ensure the viability of the group at the expense of the individual. In order for bacteria to gain a selective advantage over rivals and to persist in austere environments, many species have developed robust sensing, reporting, and communications architecture built into their metabolic network. We discuss our efforts to engineer these natural sensor components by connecting them to fluorescence reporter systems in order to build field-hardened and flexible biosensor circuits capable of assessing and reporting small molecules of interest to the warfighter.

KEYWORDS: Bacteria, Biosensors, Bioengineering, Genetic Circuits, Fluorescence

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Internship at the Australian Army Malaria Institute: The DSTO Fabric Trial

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Treated fabrics have been used to provide mosquito protection for both U.S. and Australian soldiers for the past 20 years.[1] Permethrin is the insecticide of choice for both military organizations, but the rate loss of Permethrin from washed treated fabrics is variable.[2] This study was conducted to analyze two variables: how washing treated fabrics changes the effectiveness of the insecticide and which treated fabrics (Oxford, Twill, or Nomex) were most effective in knocking down and killing *Aedes aegypti* mosquitoes. We determined that the Oxford fabric was most effective in knocking down mosquitoes immediately, while the Nomex fabric was most effective in rendering mosquitoes unable to bite for the long term. Due to systematic error, it was difficult to determine how significantly the number of washes altered the effectiveness of treated fabrics. The calculated p-values indicated our results were not statistically significant due to systematic error. However, this experiment provides insight and data pointing to which fabrics to focus on (Oxford and Nomex) and confirmed that the World Health Organization test method works for future tests conducted by the Australian Defense Force.

KEYWORDS: Permethrin, *Aedes aegypti,* treated fabric, malaria vectors
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Numerical Investigation of Bending-Body Projectile Aerodynamics for Maneuver Control

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Precision munitions are an active area of research for the U.S. Army. Canard-control actuators have historically been the primary mechanism used to maneuver fin-stabilized, gun-launched munitions. Canards are small, fin-like control surfaces mounted at the forward section of the munition to provide the pitching moment necessary to rotate the body in the freestream flow. The additional lift force due to the rotated body and the canards then alters the flight path toward the intended target. As velocity and maneuverability requirements continue to increase, investigation of other maneuver mechanisms becomes necessary. One option for a projectile with a large length-to-diameter ratio (L/D) is a bending-body design, which imparts a curvature to the projectile body along its axis. This investigation uses full Navier-Stokes computational fluid dynamics simulations to evaluate the effectiveness of an 8-degree bent nose tip on an 8-degree bent forward section of an L/D=10 projectile. The aerodynamic control effectiveness of the bending-body concept is compared to that of a standard L/D=10 straight-body projectile. All simulations were performed at supersonic velocities between Mach 2–4.

KEYWORDS: Navier-Stokes, computational fluid dynamics, control

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Beam Quality Study for Single Mode Oxide-Confined and Photonic Crystal VCSELs

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A high-quality single mode beam is desirable for the efficient use of lasers as light sources for optical data communications and interconnects. To this end, we conducted a study to analyze the beam quality for a number of vertical-cavity surface-emitting lasers (VCSELs). We report on the beam quality and operating range of oxide-confined and photonic crystal (PhC) devices using M2 measurements, voltage and optical output power versus injection current (LIV), and spectral content. We used the collected LIV data to find the operating range of the devices and then characterized the devices over the operating range both in terms of spectral content and M2 value. For single mode devices (characterized as a having a Side Mode Suppression Ration (SMSR) > 20 dB), we further characterized the devices in terms of the root-mean-square (RMS) linewidths. The devices that we use for these characterizations are emitting at ≈850 nm with oxide-confined apertures of 2.5 μm, 3.0 μm, 3.5 μm, 4.0 μm, and 4.5 μm and PhC devices with apertures of 5.0 μm and 10.0 μm. The measured M2 values for the oxide-confined VCSELs suggest that the beam propagation factor improves with decreasing aperture size (with the 2.5 μm aperture devices exhibiting near single mode operation across their range of operating currents). PhC VCSELs demonstrated lower M2 values than oxide-confined devices with the same aperture and similar injection current.

KEYWORDS: VCSEL, Photonic Crystal, Oxide-Confined, Operating Range, Beam Quality

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Small-Unit Water Purifiers in U.S. Army Special Operations: A Multi-Attribute Evaluation

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During the US military's first 145 years, waterborne and other infectious diseases caused more casualties than battlefield injuries. Such historical data highlight the importance of clean drinking water to the success of US Army special operations forces (SOF). Ensuring drinking water safety poses special challenges to such SOFs, in part because treatment equipment used in the conventional Army is too heavy and operationally complex to deploy to remote outposts. This research applies multi-criteria decision analysis to identify a preferred commercial off-the-shelf water purifier for use by SOF in remote environments. Using feedback from seven Army public health professionals and end users, four water purifiers were identified to evaluate against nine performance criteria. Then, four different methods were used to elicit a multi-attribute value function to identify the system best meeting the needs of a US Army SOF Environmental Science and Engineering Officer whose unit has been assigned to a remote region of Afghanistan. Regardless of method choice, the same preferred technology was identified. The results illustrate the robustness of multi-attribute value theory in selecting a preferred technology when there are multiple performance objectives and no single technology best meets any single objective.

KEYWORDS: multi-attribute value theory; military; drinking water

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CHARACTERIZATION OF COMMON RDX DEGRADATION PATHWAYS USING GCMS AND PROTON NMR

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RDX is a chemical component that is commonly used in the majority of military explosives and ordinance. Due to its high usage by the military, RDX residues left over from explosions can be found nearly anywhere military training or action has been observed. Knowledge of what side products are formed from RDX in different environments could be pivotal in producing agents that could nullify the environmental effects of RDX degradation. Additionally, knowing the rate at which RDX degrades in different environments could help identify at risk environments as well as different pathways for degradation.

Experiments were conducted to analyze RDX degradation rates via proton NMR and Gas Chromatography/Mass Spectrometry at different concentrations of sodium persulfate and at different temperatures. NMR spectra showed changes over time, but the symmetry of RDX and the complexity of the mixture prevented interpretation of the spectra. Although GC/MS analysis shows differences in the rate of degradation given different temperatures and different concentrations, determining reaction kinetics will require additional data. This talk will discuss results obtained so far and propose additional experiments to develop conclusive results.

KEYWORDS: RDX, Gas Chromatography and Mass Spectrometry, Proton NMR.

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