Three-dimensional face reconstruction from the infrared polarimetric measurements

Alex J. Yuffa and Gorden Videen, ARL

The ability to identify a person based on a photograph is important in many different defense and security applications. Typically, these photographs require an active source of illumination and only provide a two-dimensional map of the subject's face. It is possible to form a three-dimensional (3D) reconstruction of the face from these photographs, but to achieve this, photographs of multiple points of view of the subject are required. At night, it might not be possible to have sufficient illumination to form a high fidelity image of the subject. Furthermore, the formation of multiple-points-of-view images might not be feasible. We propose that it might be possible to obtain a reasonable 3D reconstruction of the subject's face from a *single* point of view and *without* an active source of illumination via an IR polarimetric camera. An IR polarimetric camera measures the Stokes parameters (S_0, S_1, S_2 and $S_3 \approx 0$), from which a 3D face reconstruction might be possible.

KEYWORDS: Imaging systems, Infrared, Polarimetric imaging

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Optimizing Head-space Analysis of Explosives

CDT Theodore Kostich, CDT Dillon Svoboda, and Dr. Dawn Riegner, USMA

Devices used for the detection of explosives are critical for the soldier and homeland security. Being able to make the detection in a field-able device is very advantageous to all who are at risk. However, before the detection technology can be perfected it is important to understand what kinds of detectable signatures are traceable to the explosives. This study focuses on the use of solid-phase micro-extraction (SPME) fibers as a means to adsorb any head-space chemical signature that might be attributable to the explosive, and then gas chromatography with mass spectrometry (GCMS) detection for the analysis and identification of the chemical signature. Several explosive compounds were analyzed and optimization of fiber material and instrumental conditions was performed.

KEYWORDS: SPME, explosives, head-space

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Context Monitoring for Real-World Neuroimaging Experimentation

Dr. Gregory Apker, Dr. Tracy Jill Doty, Dr. W. David Hairston, and Dr. Kaleb McDowell, ARL

To study the brain's response to stress in the real-world, we must abandon event-based stimuli traditionally used to induce and measure the neural response in the laboratory. Instead, we must rely on well characterized physiological responses in the real world to inform analysis of the neural signal. To study the effects of real-world stress on brain activity, we have designed a system that integrates cardiac, respiration and electrodermal signals with accelerometry to develop a rich contextual picture of the events in a person's day that may contribute to perceived stress. Participants are equipped with a BioHarness 3 to record ECG and respiration, as well as a Q-Sensor to monitor electrodermal activity. Additionally, a MINDO 32-channel wireless EEG system simultaneously collects neural data from the participants. During the eight hour recording session, data from the MINDO, the BioHarness, and Q-sensor are wirelessly streamed to a handheld device which synchronizes the data and collects user input. From the physiological sensor data many salient biometrics are extracted and then compared to determine specific patterns of correlations between features over time, as well as during periods in which the participant's activity is known. These features and patterns can then be used to ultimately generate detection algorithms to distinguish between changes in the physiological signals due to stress from other environmental and contextual factors. This information is critical to identifying the correct periods of interest for further analysis of the EEG data related to real-world stress.

KEYWORDS: Neuroimaging, Context Monitoring, Sensor fusion, Stress

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PixSend: Web-Enabled Target Localization and Reporting

Stuart P. Baker, USMA and William Truran, Picatinny Arsenal

For soldiers in the field, the task of quickly, accurately, and reliably determine the location of a target is challenging. Even once the target has been located; it is difficult to accurately and coherently convey that information to those who need it. The goal of this project was to design a system to reduce the difficulty of localizing and reporting a target to the chain of command. Our lab modified an existing laser rangefinder and coupled it with a camera and an embedded computer to create a handheld device that can upload a target image, calculated grid coordinates, and other information to a central database for analysis. Our device reduces the target localization time to less than three seconds and provides a feedback mechanism for commanders. The PixSend device has the ability to significantly lower the risk to soldiers by reducing their exposure to the enemy, provides commanders with a near-instant feedback mechanism, and catalogs data for future analysis.

KEYWORDS: Target localization

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Materials Science Under Extreme Conditions at the Army Research Laboratory

Jennifer A Ciezak-Jenkins, ARL

The study of matter at extreme conditions of pressure and temperature represents a forefront area of research activity across multiple fields of sciences. During the last few years, researchers at the U.S. Army Research Laboratory have been using high-pressure techniques as part of an effort to investigate innovative approaches that will ultimately enable revolutionary advances in lethality capabilities. An overview of the high-pressure facilities and capabilities at the U.S. Army Research Laboratory will be presented and opportunities for collaborative research will be discussed.

KEYWORDS: High-pressure, Extreme Conditions, Lethality

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Beyond the Weight – Biomechanical and Physiologic Effects of Load Distribution during Military Load Carriage

Dr. Angela Boynton, ARL

Dismounted Soldiers routinely carry substantial loads consisting of clothing, weapon, ammunition, personal protective equipment, communications systems, and a rucksack containing food and other necessary items. While the biomechanical and physiological effects of overall military loads and their impact on Soldier task performance have been studied, little attention has been paid to the independent effect of load distribution. Recent studies have sought to quantify the effect of distributing load between the trunk, rucksack and hands on select biomechanical and physiologic variable. Changes in oxygen consumption, trunk kinematics, trunk-pelvis coordination, muscle activity, spatiotemporal gait parameters and ground reaction forces are presented. The potential impact of these differences on Soldier mobility and shooting performance is discussed and future areas of related research are highlighted. The results from this line of research can be used by mission planners to better evaluate trade-offs between equipment needs and mission outcomes and by developers to more optimally design load carriage systems and manually carried Soldier equipment.

KEYWORDS: Energy Expenditure, Kinematics, Kinetics, Muscle Activity, Coordination, Gait

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SWIPES System and Solar Power in the Field

CDT Daniel Blaine, CDT Kevin Blash, and CDT Benjamin Hatton, USMA

For this project, research was conducted on the capabilities of portable solar panels and their use in the military. Using the Goal Zero Nomad 7 Solar Panel, the voltage and power generated by the panel were found under various controlled conditions, and a field test was completed to test the panel's effectiveness in random conditions. DIY Modeling was utilized to simulate how various radios can be charged with the SWIPES (Soldier Worn Integrated Power Equipment System) gear, showing the power generated based on latitude, time of year, time of day, and sky conditions.

KEYWORDS: Solar Panel, SWIPES, DIY Modeling

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Identification of Tasks for Evaluating the Interaction of Physical and Cognitive Performance

Dr. H. Philip Crowell, Kathy L. Kehring, Rhoda M. Wilson, and Dr. Ellen C. Haas, ARL

Currently, dismounted Soldiers use a variety of communication, navigation, and information systems while they are walking and carrying loads. In the future, such systems will provide Soldiers with additional capabilities to enhance their knowledge of the battlefield. Operation of these systems requires cognitive resources while Soldiers are exerting themselves physically. Thus, there is a need to understand how physical performance and cognitive performance interact so that design specifications and Soldier performance models can accurately reflect capabilities of Soldiers. Researchers have found that physical exertion can enhance, impair, or make no difference in cognitive performance depending on the task. In many of these studies however, the cognitive tasks are not relevant to the duties of dismounted Soldiers. Recent experiments at the U.S. Army Research Laboratory, Human Research and Engineering Directorate examined the interaction of physical and cognitive performance for tasks that are commonly performed by dismounted Soldiers. Results indicated that for an object identification task the percentage of objects identified correctly is affected by the speed at which the Soldier travels. Also, response time for an auditory monitoring task is influenced by whether or not the Soldier carries a load. Thus, for the conditions examined, object identification and auditory monitoring are two dismounted Soldier tasks, that show the interaction of physical and cognitive performance.

KEYWORDS: Dismounted Soldier, Tasks, Capabilities, Speed, Load

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Emergent Leader Immersive Training Environment (ELITE)

CDT Brian Delgado, USMA, Matthew Bosack, Mark Core, Matthew J. Hays, Chirag Merchant, Mike Birch, Julia Compbell, Arno Hartholt, Kip Haynes, and Matthew Trimmer, Playa Vista

The Emergent Leader Immersive Training Environment (ELITE) targets leadership and basic counseling for junior leaders in the U.S. Army. The ELITE experience incorporates a virtual human, classroom response technology and real-time data tracking tools to support the instruction, practice and assessment of interpersonal communication skills. In an effort to provide a structured framework for teaching and practicing communication skills, ELITE replaces one human role-player with a life-sized virtual human. The virtual human component addresses the issues inherent to live role-play practice sessions that cannot be easily standardized, tracked and assessed following the interaction.

KEYWORDS: ELITE, ICT, USC, Emergent, leader, immersive, training, environment

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Character Protocol Creation and Scenario Development for a Pedagogically-Oriented Negotiations System

CDT David Grossman, USMA

Artificial intelligence capable of negotiating with a human for the purpose of teaching negotiating skills to Army personnel. This piece of AI, or agent, is based on principled negotiation and seeks to create a realistic interaction with the user through negotiating—the primary goal being to allow Army personnel the chance to learn or practice negotiation skills. The agent will take a wide variety of inputs into account, to include both verbal and non verbal, in order to evaluate the efficacy of the user in the given scenario, and respond accordingly. This project is in the preliminary stages of development.

KEYWORDS: Principled Negotiation, Army Trainer, ICT

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When changes are missed: Spatial and semantic influences on auditory change deafness

Kelly Dickerson, Ph. D. and Jeremy Gaston, Ph. D., ARL

Laboratory studies on sound identification demonstrate that humans are incredibly sensitive to changes in the acoustic environment. However, typical real-world environments, and especially urban environments, are much more complex and acoustically varied than that studied in most laboratories. In complex listening environments identification of changes is quite poor, so much so, that listeners often fail to notice large and salient changes in the acoustic environment. These large errors are indicative of the phenomena of *change deafness*, and suggest that sensory representations are not verbatim copies of the external world, but are lacking in potentially important details. For the Soldier, inaccurate or insufficient information about the external environment can have a detrimental impact on situational awareness, and thus mission safety and success. The current study examined errors in change detection and identification performance for complex sound scenes comprised of various environmental sounds. Participants heard a brief auditory scene (1000ms) comprised of four sources followed by a scene where a sound source was either added or subtracted from the scene, or no change occurred. There were two listening conditions, where the sound sources were each distributed across a loudspeaker array, or the sound sources were all played from a single loudspeaker. Results indicate that listeners were better able to detect appearing than disappearing sounds, and fewer errors were made when sound sources were spatially separated. Further, we found that the specific identity of the items in the scene influenced the likelihood of detection. Specifically, detection was best when the changed item was semantically distinct from the other sounds in the scene.

KEYWORDS: Change Deafness, Perceptual Similarity, Sound Source Perception, Auditory Change Detection

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A Systematic Multi-scale Approach to Develop an Experimental Framework to Understand Blast TBI Mechanisms

Ann Mae DiLeonardi, Ph.D. and Tusit Weerasooriya, Ph.D., ARL

Over the past decade, the incidence of blast-induced Traumatic brain injury (TBI) has risen substantially. Scientists are currently working to elucidate the pathophysiology and mechanisms of this type of injury. The constellation of neurobehavioral symptoms observed in long-term blast survivors suggests that this is a mild TBI. In the civilian population, and likely the military population, a hallmark of mild TBI is diffuse axonal injury (DAI). In animals, DAI is manifested as traumatic axonal injury (TAI), which results from a combination of mechanoporation of the axolemma, focal loss of microtubules, ionic dysregulation, impaired axonal transport (IAT) and neurofilament compaction (NFC). Diffuse brain injury in the rat resulted in single-cell structural deficits (neurofilament alterations, impaired axonal transport, and axonal degeneration) and a lasting impaired population response (changes in compound action potential) leading to chronic behavioral deficits (impaired learning and memory). This multi-scale understanding presented a unique opportunity to investigate the mechanisms of injury relating cellular scale measurements to higher scale behavioral response following TBI as well as to determine efficacy of potential therapeutic targets. In the first part of the study, I investigated the hypothesis that inhibition of the calcium-dependent phosphatase, calcineurin, would attenuate axonal injury and observed attenuation of injury-induced neurofilament alterations and axonal degeneration. However, I did not observe an effect on impaired axonal transport or CAP; therefore I did not proceed with the behavioral study. In the second therapeutic study, I tested the hypothesis that inhibition of the calcium-activated protease, calpain, would attenuate axonal injury. I observed that this treatment significantly attenuated calpain activation; however, this treatment was unable to decrease injury-induced impaired axonal transport, neurofilament compaction, axonal degeneration, or compound action potential deficits leading me to not conduct a behavioral study. Importantly, these data are indicative of the heterogeneity of mechanisms underlying axonal injury in the traumatically-injured brain. By means of these research experiences from cellular-scale to behavioral scale, at ARL, I am working to develop experimental methods and facilities to understand the mechanical, electrical and chemical (MEC) responses of biological cells to mechanical loading at different rates, especially extreme loading rates relevant to the Army. I am eager to help to incorporate cellular scale research to the ongoing multi-scale high rate experimental mechanics research at the Army with the goal of understanding blast injury mechanisms.

KEYWORDS: Blast, Traumatic Brain Injury (TBI), Axonal Injury, High-rate experimental mechanics, Multi-scale, Calcium, cellular-scale

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ARL Robotics Enterprise: Goals, Programs, and Results of the Human-Robot Interaction Domain

Dr. A. William Evans III and Dr. Susan G. Hill, ARL

Through in-house research, as well as government and academic partnerships, human-robot interaction (HRI) research has continued to expand within the U.S. Army Research Lab (ARL). Research in the areas of human-robot teaming, trust in automation, scalable displays, and operator aids is providing critical information that has aided the integration of autonomous assets into human teams. For example, research conducted to investigate the effects of visual display aids on human operators has shown that certain types of aid information can help to reduce cognitive workload, while also requiring less direct interaction between Soldiers and robots. These effects could allow Soldiers more cognitive and temporal resources to devote to situation awareness tasks and could increase mission effectiveness. The *poster* will include information on the ARL Robotics Enterprise as well as HRI mission research conducted by the Human Research and Engineering Directorate. I will also give a demonstration of an exemplar interface being studied to support Soldier-robot teaming. [Requirements: 2 poster stands; 1 small table with an electrical outlet].

KEYWORDS: Human-Robot Interaction, trust in automation, operator aids, workload

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Internal Strain in Nano-Diamond and Boron Nitride

Dr. Donald Johnson and Dr. William Mattson, ARL

Nanodiamond surfaces undergo reconstruction imposing stress on nanoparticle (NP) core and possibly storing large amounts of strain energy. The unique way in which these NPs store energy may lead to useful applications, but a greater understanding of strain energy storage/release is needed. In the current work, density functional theory methods are employed to predict structural properties and energetics of C (diamond) and cubic-BN NPs. The goal is to quantify NP core stress and its relationship to surface rearrangement, particle size, and material composition. Initial results suggest different chemical factors drive surface rearrangement, leading to compressive stress in C and tensile stress in BN.

KEYWORDS: Energetic materials; density functional theory; carbon; nanodiamond

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Using IMPRINT to Identify Targets for Intelligent Tutoring

CDT Trent Reece, CDT Katherine Mucke, CDT Alyssa Sohn and COL James Ness, USMA and
Dr. Benjamin Goldberg and Dr. Robert Sottilare, ARL

Developing technology for the Warfighter is a complex endeavor. Developing technology-based training to support these emergent capabilities adds to the complexity. Initial research and development efforts traditionally take into account producing a function to meet a need, oftentimes ignoring elements that impact system effectiveness as it evolves through the acquisition lifecycle. A functional area recognized as being critical to successful transition from the lab to the field is 'trainability', requiring early involvement by Human Factors Engineers to recognize system components and functions that must be learned by eventual system operators. To ease the burden of this process, the U.S. Army Research Laboratory's Improved Performance Research Integration Tool (IMPRINT) is being researched to determine its application as an instrument to identify 'trainability' issues that can be used to support training design practices. We will present a collaborative project between USMA and ARL that uses IMPRINT analysis techniques on an emerging technology to identify targets for intelligent tutoring. An IMPRINT model designates behaviors and chains of behaviors that are explicitly linked to system operation. The resulting model is used to assess operator workloads across tasks, with results providing insight into processes likely to challenge a system operator and behaviors that are reactionary in nature based on conditions inherent to the operational environment. The goal is to optimize training practices by building systems to support the tasks deemed most critical to system function and recognizing processes that are prone to decay over time. The development and results of an IMPRINT model generated for a trainability assessment on a complex system under development is presented. The poster includes steps for establishing functions and tasks that make up the model, the inputs collected and processes defined, and how the resulting model will be used to identify targets for supportive intelligent tutoring applications.

KEYWORDS: Trainability, Workload, IMPRINT, Intelligent Tutoring Systems, Task Analysis

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Synthesizing Load Profiles for Forward Operating Bases

CDT Thomas Hart, Dr. Aaron St. Leger, and CPT Jeremy Spruce, USMA

Energy is a mission critical commodity for the military. Without fuel to support energy needs, Soldiers would be rendered combat ineffective. Petroleum based generators are presently the primary energy source for Forward Operating Bases (FOBs). The required transportation, security, and principal costs of fuel create less than ideal operating conditions. This work is part of a larger effort to develop micro-grid technology for FOBs with the aim to improve energy efficiency, integrate renewable energy sources, and decrease the dependency on fossil fuels. One challenge in this work is to accurately model electric load demand over time for FOBs which is a key component in system design and development of microgrid technology. Some field data is available but the fidelity and usefulness for the development of future FOB power systems is questionable due to the uncertainty in location, size, and mission scope of future FOBs. The approach taken here is a bottom-up synthesis of a FOB load profile that can account for the aforementioned uncertainty. The intent is for a flexible tool to facilitate the development and incorporation of evolving micro-grid technology on FOBs. Load profiles for individual components are derived from historical and experimental values. The aggregate FOB load profile is synthesized from this data and specified user defined parameters such as FOB size, type/number of structures, and geographic location. This accounts for each individual component and is flexible for studying current and future FOB power systems. A preliminary version of this tool has been developed in LabVIEW software and will be integrated into a microgrid laboratory at the United States Military Academy. More specifically, results that have been achieved so far include the development of scalable Tactical Operations Center (TOC) and living quarters load profiles based on equipment used in the past. Future work includes introducing additional components and adding random variability into the profiles.

KEYWORDS: Micro-grid, forward operating base, energy, power, load profile

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Comparison of Real World, Immersive, and Desktop Simulation Environments for Evaluating Cognitive and Physical Perf on Dismounted Soldier Navigation Tasks

Kathy L. Kehring, Dr. H. Philip Crowell, and Rhoda M. Wilson, ARL

There are various research environments that can be adapted to study the effects of cognitive and physical workload on dismounted Soldier performance. The degree of realism of the tasks performed in these environments as well as the level of control of the variables in these environments may have an effect on performance. A study was conducted to evaluate research environments at the U.S. Army Research Laboratory, Human Research and Engineering Directorate to determine which were appropriate for specific types of physiological and cognitive research involving dismounted Soldiers. One of the tasks, a dismounted navigation task was performed in three different environments: a real world outdoor environment, an immersive environment simulator, and a desktop simulator. The real world environment was a series of several warehouse buildings with roads or pathways between them. The simulated environments provided a virtual representation of the terrain in the real world environment. In the immersive environment, the virtual terrain was displayed on a four-sided CAVE display system and the Soldiers maneuvered through the environment by walking on an Omni-directional Treadmill. In the desktop environment, the Soldiers sat in a chair in front of a computer monitor and maneuvered using a joystick with the speed of travel limited to a maximum of 4 mph. (approximate walking speed). In each environment the Soldiers used a map to navigate a prescribed path around the warehouses. Performance measures included completion time, oxygen uptake, heart rate, and number of errors. Completion time for the navigation task in the immersive environment was longer than in the real world environment; however, there were no significant differences in oxygen uptake or heart rate between these two environments. Although there were no significant differences in the navigational errors, there were more errors in the desktop simulator environment with its restricted field of view than in the immersive environment simulator or the real-world environment. The data indicates that, if permitted to set their own pace, the physical workload and cognitive performance experienced by the participant in the immersive environment simulator is representative of what can be expected in the real world however speed of travel will be slower. The desktop simulation requires minimal physical workload as compared to the real world and may produce more errors. Also, participants tend to travel at maximum speed continuously so if maximum speed is not limited, participants will likely travel at a speed that would be unrealistic and unsustainable in the real world. Knowing how these environments affect different aspects of performance will aid researchers in determining which environment to use in future studies of cognitive and physical performance.

KEYWORDS: Physical workload, Cognitive workload, Navigation, Immersive Simulation, Omni-directional Treadmill

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Research Conducted by ECBC's Point Detection Branch

Benjamin Lacey, USMA

The Point detection branch at Edgewood Chemical Biological Center's main focus is developing new more efficient techniques to detect biological and chemical threats in various matrices. By combining knowledge from different scientific disciplines the researchers at the point detection lab developed a technique to quickly identify bacterial and viral strains in multiple matrices. The researchers describe their method as "an integrated and automated software application for rapid bacterial identification using a relational database management system and liquid chromatography electrospray-ion trap mass spectrometry (LC-ESI-MS). LC-ESI-MS is used to generate chromatographic profiles of proteins in a bacterial sample along with a software program that automates the data analysis." Classification of Tandem Mass Spectrometric Data, Deshpande et al. J Chromatograph Separat Techniq 2011, S5

KEYWORDS: LC-ESI-MS, ABOid, Edgewood Chemical Biological Center

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Environmental Toxicology Lab AIAD

CDT Junyoung Lee, Dr. Michael Simini, Dr. Roman Kuperman, andDr. Carlton Phillips, ECBC

CDT Lee was given many assignments throughout his three weeks at the Environmental Toxicology Lab. In addition to touring the Edgewood Chemical Biological Center and viewing the variety of labs and engineering buildings that the base had to offer; he also had the opportunity to aid in some ongoing experiments. His jobs ranged from lab prep, to feeding worms, to renewing cultures for the experiments. CDT Lee was able to experience first-hand what working in a professional lab was like and the amount of preparation required before beginning a new experiment. Cadet Lee worked in the Environmental Toxicology Lab during the three weeks at ECBC. The majority of his time there was spent prepping future experiments that were to be conducted in the upcoming weeks. Some of jobs included cleaning jars for the cultures, feeding and harvesting the worms that were to be used in the experiments, and filling the jars with sand and the chemicals of choice.

KEYWORDS: Toxicology, cultures, worms

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Predicting Injury from a Pitcher's Biomechanics

CDT Jonathan Lee, USMA

Using video capture points from pitching scouting videos and record days spent on the disabled list, I examine multiple positions in a pitcher's delivery in an effort to find a measure that predicts pitcher injury. The data suggest that stride length, head to hip, backside, and horizontal adduction angles are statistically significant predictors of days spent on the disabled list by professional pitchers. The novel nature of this study leaves little room for comparison but opens the door for future work in the analysis of player biomechanics and their effect on player injury at the Major League level. The results suggest that purchasing software to further analyze pitcher biomechanics is a worthwhile endeavor.

KEYWORDS: Biomechanics, Major League Baseball, Pitcher, Sabermetrics,

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Confidence Metrics Improve Human-Autonomy Integration

Amar R. Marathe, Brent J. Lance, William D. Nothwang, and Kaleb McDowell, ARL and Jason S. Metcalf, DCS Corp.

Controls frameworks for human-autonomy integration (HAI) often treat human sources of information as highly reliable. However, data from human sensing are quite variable, both because of human nature and limitations on sensor technologies. This study focuses on estimating the degree of uncertainty in human sensed data, i.e., developing confidence metrics, and implementing those metrics in a HAI for target recognition. Here we demonstrate that applying such confidence estimates to sensed human data can mitigate effects of variability in terms of reduced reliability in human sensing and improve HAI performance.

KEYWORDS: Operator interfaces, artificial intelligence, confidence, human-robot interaction, algorithms, design, reliability, human factors

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The effects of sustained cognitive and physical load on Soldier performance and electrocortical dynamics

Dr. Jamie R. Lukos, Dr. Kelvin S. Oie, and Dr. Keith W. Whitaker, ARL, Dr. J. Cortney Bradford and Dr. Daniel P. Ferris, U of Michigan, and Dr. Jason S. Metcalfe, DCS Corp.

The main purpose of this study is to better understand the physiological and behavioral responses during sustained tasks that are simultaneously physically and cognitively demanding. Understanding the way the body responds and how performance changes during complex physical-cognitive tasks remains unclear, particularly in operationally-relevant conditions. To investigate this, participants perform a physical task (walking while carrying a loaded Army-issue rucksack) while also executing a cognitive task (visual target detection). While performing this dual task, participants are outfitted with a novel combination of recording devices to record brain activity (electroencephalography, EEG), muscle activity (electromyography, EMG), heart rate, temperature, movement biomechanics (acceleration and force production), and task performance. Participants are also are periodically sampled for hormonal fluctuations (salivary secretions) and undergo psychological evaluations (questionnaires). With this robust set of data, we will gain unique insights into the behavioral and physiological basis of physical and cognitive interactions, as well as determining which computational techniques are most effective in detecting/predicting changes in Soldier performance. The knowledge resulting from this study could help to develop better monitors of Soldier health and effectiveness, enhance scheduling of tactical deployments, and optimize training regimes. This project is a CaN CTA collaborative effort across ARL, the University of Michigan and DCS Corp. (Alexandria, VA). Data collection is currently underway at the ARL Solider Performance and Equipment Advanced Research (SPEAR) facility and preliminary data analyses techniques are being tested.

KEYWORDS: Mobile brain imaging, human locomotion, multi-sensor integration, computational neuroscience, motor control

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Developing a Model of the Circulatory System that Considers the Effects of Heart Rate Variability and Exercise Intensity

CDT Mark C. McCormick and Dr. William Brechue, USMA

The heart is a rhythmical pump which generates a force that gives rise to the system's fluid pressure, and thus can be modeled through thermodynamic principles as a pump system. Recently, much has been made about the importance of rhythm variability in biological systems in optimizing function and reducing system fatigue. Interestingly, computational models of the cardiovascular system have not placed a high degree of consideration towards an understanding of how non-constant variables such as Heart rate rhythm variability, Traube-Hering waves, aortic reflective waves, body water minute waves, and arterial and venous wall elasticity regulate pressure and cardiovascular function. The purpose of this study is to understand how such factors could influence rhythm variability to create a more authentic model of the heart. The focus of this particular study is to further analyze the impact of heart rate variability (HRV) on the cardiovascular system by considering different types of physical activity such as long distance running, weightlifting and cross-fit exercises over an extended period of time and their effect on cardiovascular function. Through the analysis of experimental data, a preliminary computer simulation model for a cardiovascular pump system was designed and simulations were performed to understand how the work output of the heart changes with the degree of heart rate variability.

KEYWORDS: Heart Rate Variability, Cardiovascular System, Reciprocating Pump Design, Autonomic Nervous System

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Software Defined Networking (SDN)

Dr. Vinod K. Mishra, ARL

SDN is a new networking paradigm in which the basic idea is the separation of the control plane from the data plane. In the traditional networks, both are integrated and this makes any programmability and change in the network virtually impossible. At the ARL, we have set up a Global Environment for Network Innovations (GENI) node, which is the most popular platform for SDN research and experimentation. We have also started setting up the DOD GENI Authority (DGA) capability, which may become the resource broker and authentication agent for all of the current or planned GENI nodes inside DOD. The SDN research team at ARL is currently active in the areas of Cognitive Controller and Unified MAC Layer Access using modeling and simulation tools.

KEYWORDS: SDN, GENI, DGA

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Cyber Operations through Mission Command: Using Network Analysis to develop Contingent Command and Control Strategies for Tactical Communication during the Information Age

CDT Matthew Moellering and Dr. David Arney, USMA

For all military units, securing the passage of information has been crucial since the dawn of warfare. As critical systems and communications increase reliance over networked and linked devices, vulnerability to a crippling cyber attack also increases. For current mechanized and mobile formations in our Army this increase in reliance on these systems allow for unprecedented potential for the sabotage and compromise of our communication networks. This model demonstrates the current communications structure of the members of a standard Stryker Infantry Company, the most modern infantry regiment in our Army. From there Mission Command principles allow for the analysis of which leaders will have control over the unit depending on the networks that receive attacks.

KEYWORDS: Network Analysis

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Large DFT: to 100K atoms and beyond.

Dr. Jonathan Mullin and Dr. William Mattson, ARL

A quantum mechanical (QM) approach to materials science provides a gold standard atomistic picture of the mechanisms responsible for a range of phenomena seen in macroscopic and experimental situations. The need to understand materials science problems from atomistic to macroscale was the impetus for ARL to initiate the Enterprise for Multiscale Material Research. This long term project attempts to redefine how materials science questions are posed, and solved. To support this goal, current state-of-the-art QM capabilities need to be extended in the number of atoms which can be treated and the length scale of the dynamics which can be simulated. This extension is referred to as large scale QM, both large spatially and temporally. This will enable fundamental advances in the understanding of materials science problems.

KEYWORDS: Linear scaling; density functional theory; purification; sparse matrix; Fragmentation

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Surface Mechanical Attrition Treatment:

Dr. Heather Murdoch, Dr. Kris Darling, Dr. Laszlo Kecskes, A. Roberts, and T. Cook, ARL

Surface Mechanical Attrition Treatment (SMAT) induces a grain size gradient to a metallic substrate, imparting superior strength to the surface through grain refinement to the nanocrystalline or ultrafine grain scale, while maintaining the overall ductility of the part. Recent work at ARL has developed a SMAT treatment at cryogenic temperatures, changing the deformation mechanics active during processing. This results in an increased reduction in grain size as compared to ambient SMAT processes, and significantly changes the gradient grain distribution. Stemming from these appreciable differences in grain size distribution are distinct grain growth behaviors. We also examine the effect of ambient and cryogenic SMAT processes on the texture of the substrate.

KEYWORDS: Ultrafine grain, Surface treatment, Cryomilling, Grain size gradient

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Assessment of Mutations in Outer Membrane Proteins on the Fitness & Virulence of Acinetobacter baumanni

Jamison F. Tate, Jacob T. Scoggin, Valerie R. Coe, Christopher M. Husson, Nicholas A. Moran, MAJ Ford M. Lannan, and COL Carl C. Brinkley Ph.D., USMA

The virulence factors of *Acinetobacter baumanni* (AB), an emerging opportunistic pathogen that has recently gained notoriety due to its propensity for prolonged survival in a desiccated state, prevalence in hospital-acquired infections, and ability to acquire multi-drug resistance, have been partly attributed to surface and transmembrane proteins. In order to further elucidate the involvement of these proteins with AB's pathogenicity, clones from a transposon library with disruptions in putative outer membrane sequences were tested against its parental wild-type strain with various bacteriolgical assays. As a result, we have begun to expand our understanding of the epidemiology and strain evolution of *Acinetobacter baumanni*.

KEYWORDS: Acinetobacter baumanni, outer membrane protein

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American-German Military Relations and Analyses of Contemporary Weaponry

CDT Connor Santana, USMA

Throughout the duration of the AIAD in WTD91, Germany, a variety of developing weapon technology was tested. WTD91 is the German research and weapon testing facility for rocket propelled weaponry. Through disassembling MLRS's, observing tests fires of the Panzerfaust III, and incorporating different fuses, I was able to understand how advancing German technology compares with our own. The language barrier was an interesting variable throughout my experience there as well. Given the close-knit relationship between the United States and Germany, it was interesting to see how weapon technology in Germany mirrored that of ours and vice versa.

KEYWORDS: MLRS, WTD91, Panzerfaust III, Bundeswehr

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Big Data Challenges – Information Overload and the Squad Leader

Debbie Patton and Laura Marusich, ARL

Decision-making of individuals within an Army network, how it affects and is affected by communications and information flow within the network needs investigation. With the rapid increase in available information brought about by the US Army's transition to Network Enabled Operations (Alberts & Garstka, 2004), the Big Data Challenges (volume, variety, velocity and veracity) become an issue for Soldier performance at the mission command and squad leader levels. Fundamental research is required to understand the relationship between these variables and cognitive performance, particularly in the military domain. In an effort to understand these relationships, we propose a study to manipulate the amount and rate (volume and velocity) of information presented to participants, and assess the participants' decision-making accuracy, and task completion times in each condition. The proposed research will begin with a focus on the squad leader and be performed in the Immersive Cognitive Readiness Simulator (ICoRS) in an attempt to replicate a squad leader in his/her environment versus a commander in a mission command environment. Once these variables are understood, it is important to consider how a stressful environment will effect decision-making accuracy and task completion times. Stress can be introduced by using the ICoRS.

KEYWORDS: Network science, cognition, performance, decision-making, big data, military

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Methods of Gamma-Ray Spectroscopy

CDT Ronald F. Suarez Jr. and Paul Asare-Agyapong, USMA

Different graphs of gamma-ray spectroscopy are presented. The development of these graphs required positioning different sources near a detector, acquiring data, and then using computer programming to construct the graphs. The detectors were first calibrated using known sources with distinct photoelectric peaks. This work develops graphs that can better identify isotopes using their energy peaks.

KEYWORDS: Gamma-Ray Spectroscopy, Scintillation Detectors, Photoelectric Effect, Compton Scattering, Pair Production

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Object and Material Scene Parsing into a Knowledge Base for Image Understanding

Douglas Summers-Stay and Dr. Clare Voss, ARL, Andrew Liu, U of MD, and CDT Philip Peavyhouse and CDT Samuel Skillman, USMA

We demonstrate a system for labeling scenes by object and material, and integrate this into the ResearchCyc knowledgebase to allow for rich semantic queries. The system is able to make use of its knowledge of the facts about the world to improve estimates of both object and material labels, and to perform deductive reasoning in order to answer questions about the scenes in natural language.
This summer project was initiated as a way to build on the results of the SUBTLE (Situation Understanding Bot Through Language And Environment) multi-university research initiative. By incorporating computer vision and a richer world model, we hope to explore how such a system might be used in real-world environments.

KEYWORDS: Computer Vision, Image Understanding, Language and Vision, Semantic Knowledgebase

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Improving Security at the United States Military Academy and *Interrogator*

CDT David Su and CDT John M. Graham, USMA

An analysis of the United States Military Academy computer system network and its defenses is presented. The analysis is conducted with a prototype network research tool (Interrogator). Suggestions of alterations to the academy's network and network research tool were made for improving network security and intrusion detection efficiency. Exception handling and proper exiting prevents false positives of source code crashing, saving many man-hours in maintenance and debugging. This work presents opportunities for improvements in the existing computer systems at the United States Military Academy and the network analysis research tool Interrogator.

KEYWORDS: Computer Network Security, Exception Handling, Efficiency, Interrogator

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Photovoltaic Energy Integration for Military Operating Bases

Dr. Aaron St. Leger and CPT Jeremy Spruce, USMA

A laboratory for research in modeling and integration of photovoltaic energy sources has been developed at the United States Military Academy. The primary purpose of this lab is to support a new Alternative Energy Engineering course and research of renewable integration for microgrids. The lab consists of a PV array with battery bank storage, charge controller and inverter, programmable AC/DC loads to simulate the FOB load profile, and grid integration that simulates diesel generation utilizing LABVIEW. The laboratory supports isolated testing and characterization of PV panels in addition to grid-tied or microgrid operation with energy storage. Additionally, load control, automatic acquisition, processing, and logging of data are accomplished with a combination of commercially available software and custom developed LabVIEW software. Research focuses on analyzing FOB energy demands, renewable integration, and load control to increase efficiency of FOB microgrid operation. This laboratory supports the testing of experimental load control and renewable integration for microgrids in conjunction with ongoing research at the Army Research Labs. The following will be presented in this paper: i) the laboratory design, setup, and capabilities, ii) data acquisition iii) data processing, load control and integration, and iv) experimentation and results.

KEYWORDS: Photovoltaic modeling, education, photovoltaic integration, microgrid, energy storage

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The Biomimetics of Extremely Fast Movements

CDT Mike Taylor, USMA and Dr. Sam Stanton, ARL

Fast movements in biology remain a large, untapped resource for the engineering and robotics worlds as an example of simple, yet highly efficient mechanical systems that can move and accelerate at an astonishing rate. The mechanism in species like the bush cricket and the sand flea have been broken down, studied and analyzed. However, the workings of some of the fastest moving animals still remain untapped including that of the mantis shrimp. The shrimp's mechanism can be applied to launching projectiles, jumping robots, demolition, and battering rams, all without the use of petroleum, gun powder, or compressed gases. The goal is to learn from nature how to employ power amplification to simplify everyday machines while increasing their efficiency. This project took the four-bar linkage and spring mechanics from the mantis shrimp and applied them to a small jumping robot made with printed ABS plastic parts, a DC motor, a lithium battery, and carbon fiber rods. The objective was to create a robot that had strong jumping capabilities by limiting mass and maximizing mechanical advantage without the use of one-time sources of stored potential energy.

KEYWORDS: Biomimetics, force amplification, mantis shrimp

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The Effects of Image Probability and Salience on Averaged Event-related Brain Potentials and Single-trial Classification

Dr. Anthony J. Ries, Dr. Amar Marathe, Dr. Jon Touryan, ARL and Victor Paul, Warren, MI

Research has shown that classification algorithms accurately discriminate infrequent target-related neural features associated with the P3 event-related potential (ERP) from the neural activity associated with frequent non-target distractors in a rapid serial visual presentation (RSVP) paradigm. Much of this research has used salient target images that have generally been the only infrequent stimulus presented. It is not known if image salience and additional infrequent non-target images affect the neural features and the accuracy of single-trial classification algorithms. To address this issue we used a RSVP paradigm containing three image classes: 1) frequent background distractors, 2) infrequent targets, and 3) infrequent non-targets. Infrequent images were either moving (high salience) or static (low salience). Analysis focused on the neural activity surrounding the P3 using averaged ERPs as well as single-trial classification. Infrequent images induced neural activity similar to each other but significantly different from the frequent distracters at early P300 latencies suggesting attentional engagement to the infrequent images. Subsequent categorization was reflected at later P300 latencies where all three image classes were significantly different from each other. This pattern was found across both image salience conditions. Single-trial classification was significantly better for high compared to low salience targets; however, many infrequent-non targets were misclassified as targets. The results show that both image frequency and salience significantly affect averaged ERPs as well as single-trial classification and suggest that image classification algorithms may select neural features more associated with target frequency and less with target specificity.

KEYWORDS: ERP, P300, target detection, salience, single-trial classification

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The West Point Project for Testing Drug Sensitivity of the Malaria Parasite *Plasmodium falciparum*

Samuel Brown, Stephen Chong, Joseph Jude, Carrisa Peckny, Anthony Cox, Brittany Murray, Regina Lee, Riley Ping-Medvigy, Michaela Loomis, CPT John M Williams II MS, and COL Carl C. Brinkley PhD, USMA

In this study, the development and growth of the *Plasmodium falciparum* life cycle within the red blood cell were investigated using several analytical tools. First and foremost, the parasites were analyzed using white light and fluorescent microscopy in order to directly observe their growth. Additionally, Scanning Electron Microscopy (SEM) and Flow Cytometry were used to visualize and measure malaria growth in cultures grown invitro. A primary goal of this project is to establish an SOP for culturing Malaria for drug testing at West Point that can be easily passed from year to year as faculty and cadets rotate on and off of the project due to military obligations. Drug testing conducted thus far revolves around Melatonin combined with Artemisinin and shows promising results for activity against *P. falciparum.* This testing is the main point of discussion for this poster, but the major project of this semester was the adaptation of culturing procedures to meet the unique demands of the USMA research environment.

KEYWORDS: Malaria, Artemisinin combination therapy

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Networked Trust

Kevin Chan, Jin-Hee Cho, Ananthram Swami, and Brian Rivera, ARL

Tactical networks are multi-genre networks: a composite of interacting and co-evolving communication networks, information networks and social networks. Network dynamics and the co-evolution lead to the complexity of any networked service or policy. Using trust can improve effectiveness of decision making, leading to enhanced system performance and security. But promoting and maintaining trust is challenging in hostile, dynamic and complex tactical environments. Our work addresses several questions: How do define trust? How to assess, propagate and maintain trust? We present results from our continuing work in composite trust models and their applications to a set of networked protocols and services for tactical environments.

KEYWORDS: Network Science, Trust, Security, Performance, MANET

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Utilizing Focus of Attention for Anomaly Detection

Dr. B. J. Wimpey and Dr. MaryAnne Fields, ARL

An Autonomous Squad Member (ASM) accompanying a squad on a reconnaissance mission must be equipped to intelligently handle emergency situations without relying on directives from the human squad members. Therefore, the ASM must be able to detect when these situations occur and to react accordingly. The goal of this project is to formulate a framework to enable an ASM to utilize the movement of the squad and detect abnormalities from the statistical changes exhibited by the squad's focus of attention (FoA) over time. To do this, we reframe and extend the work of Kim et al. (CVPR2010); that is, instead of using the movement of soccer players to predict the probable location(s) of future action in a soccer game as in the work of Kim et al., the motion information from the movement of the squad is used to indicate the focus of attention of squad members. Using the statistical changes exhibited by the FoA given various situations, we will train a Support Vector Machine to classify the FoA input as normal or abnormal. As this research is a work in progress, we expect the utilization of the focus of attention in combination with a strong classifying mechanism like a Support Vector Machine will enable the ASM to detect changes in squad behavior that could signal danger, or increased operational tempo.

KEYWORDS: Anomaly Detection, Motion Field, Focus of Attention, Unity Game Engine, Simulation

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