ARL-TM-2016A ● JUN 2017

US Army Research Laboratory

Volume II: Compendium of Abstracts

by ARL Summer Student Research Symposium

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14. ABSTRACT

The ARL Summer Student Research Symposium is an ARL Director's Award Program for all the students participating in various summer scholarship and contract activities across ARL. The goal of the program is to recognize and publicize exceptional achievements made by the students and their mentors in the support of Army science.
All college undergraduate and graduate students receiving research appointments and conducting summer studies at ARL are automatically enrolled in the symposium program. As an integral part of their summer study, all students are required to write a paper on their work, which summarizes their major activity and its end product.
The program is conducted on two separate competitive levels: undergraduate and graduate. The format of the paper in both levels is the same. However, the evaluation will take into consideration the difference in the academic level of the students.
All students submitted their research paper for directorate review. Directorate judging panels selected two papers from each competition category for the laboratory-wide competition at the Summer Student Symposium on 11 August 2016.
Students selected by their directorate for competition participated in the one-day Summer Student Symposium on 11 August 2016. At the symposium, the students presented their papers to the ARL Director and an ARL Fellows panel.
This volume of the Summer Student Symposium Proceedings contains many of the abstracts for the papers prepared for the Summer Student Symposium Program.

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Director's Foreword

The US Army Research Laboratory (ARL) mission is to "provide innovative science, technology, and analyses to enable full spectrum operations." As the Army's corporate laboratory, we provide the technological underpinnings critical to providing capabilities required by our current and future Soldiers.

Our nation is projected to experience a shortage of scientists and engineers. ARL recognizes the criticality of intellectual capital in generating capabilities for the Army. As the Army's corporate laboratory, addressing the projected shortfall is a key responsibility for us. We have, therefore, identified the nation's next generation of scientists and engineers as a key community of interest, and have generated a robust educational outreach program to strengthen and support them. We have achieved many successes with this community. We believe that the breadth and depth of our outreach programs will have a significant positive effect on the participants, facilitating their journey toward becoming this nation's next generation of scientists and engineers.

A fundamental component of our outreach program is to provide students research experiences at ARL. During the summer of 2016, we supported research experiences at ARL for over 175 undergraduate and graduate students. Each of these students writes a paper describing the results of the work they performed while at ARL. All of the papers were of high quality, but only a few could be presented at our student symposium. Many of the abstracts for the papers prepared this summer are contained in this volume of the proceedings, and they indicate that there were many excellent research projects with outstanding results. It is unfortunate that there was not enough time for us to have all of the papers presented. We would have enjoyed hearing them all.

We are very pleased to have hosted this outstanding group of students for the summer. It is our hope that they will continue their pursuit of technical degrees and will someday assist us in providing critical technologies for our Soldiers.

Philip Perconti
Director

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Introduction

The ARL Summer Student Research Symposium is an ARL Director's Award Program for all the students participating in various summer scholarship and contract activities across ARL. The goal of the program is to recognize and publicize exceptional achievements made by the students and their mentors in the support of Army science.

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This volume of the Summer Student Symposium Proceedings contains many of the abstracts for the papers prepared for the Summer Student Symposium Program.

CLIVE, the Customizable Lighting Interface for Visualization of EEG signals: Code Architecture and Electronics Design

Abdali, Syed

Electroencephalography (EEG) is a neuroimaging method that allows researchers to measure the electrical activity of neurons using electrodes placed on the scalp. However, EEG activity is difficult to interpret by a general, non-expert audience, especially with large numbers of electrodes. The Customizable Lighting Interface for Visualization of EEG signals (CLIVE) was designed to be a translucent head implanted with LEDs to be used as a visualization tool for EEG signals, representing overall neural activity in different regions of the brain. In this way CLIVE produces meaningful visualizations for non-neuroscientist audiences. This is achieved by sending raw data from the EEG system to MATLAB for filtering and processing. Modularity was immensely emphasized to promote code reuse and allowed flexibility to accommodate any EEG headset. This notion was also applied to the electrical circuits by using PCB boards and a standard connector, and use of an Arduino Mega for driving the LED to simulate EEG activity. This allows for a streamlined design that requires only one ribbon cable to connect the entire circuit and easy implementation of new algorithms relating the recorded signal to a visual display. The design of CLIVE was developed to allow other researchers to integrate different experimental modes of operations.

I wish to acknowledge the mentorship of Dr W David Hairston for his guidance through each step of the process. Dr W David Hairston was able to troubleshoot any problems that arose, along with making sure the project was progressing steadily. I would also like to thank both Dr Alfred Yu and Mr Wosen Wolde for their expertise in 3D object design and electrical circuit analysis, respectively.

Cold Plates with Two Phase Flow and Internally Grooved Tubes

Argenna, Spencer

Researchers at ARL have focused on developing power-dense electronics to improve system weight, fuel usage, design flexibility, and overall functionality for a diversity of Army platforms. These new power-dense systems, however, call for better thermal management methods. In this context, the current study focuses on developing internally grooved tube cold plates to improve thermal performance and, in turn, enable this transition to more-electric platforms. First, analytical heat transfer coefficient models, along with 1-D conduction and 3-D Solidworks numerical simulations, were used to design and optimize cold plate geometric parameters and thermofluid operating conditions. The modeling results showed significant improvement of 2.5-7x for low mass fluxes between 25 and 75 $kg/m^2 \cdot s$ when comparing the grooved-tube design to a comparable smooth tube design. This predicted performance enhancement is a result of early transition to annular flow in the internally grooved tubes at lower mass fluxes. Based on the favorable modeling results, cold plates are currently being fabricated and will be tested before the end of the summer session. It is anticipated that this research will be directly impactful to ongoing efforts at ARL focusing on developing improved electronic modules for survivability and lethality of Army systems.

I wish to acknowledge the mentorship of Darin Sharar and Nicholas Jankowski.

Analysis of Kinematic Leg Design and Scaling for Dynamic, Quadrupedal Robots

Blackman, Daniel

Dynamic animal locomotion is primarily governed by the energetic properties of anatomical structures, and through the unique design and specialization of legs. These properties are often evaluated through simulation work using a standard running model for legged systems, the Spring Loaded Inverted Pendulum (SLIP) Model. In this model, the dynamics of a single leg can be explored through implementation of a linear spring located between the hip and ankle of the system. In this study, the linear spring is replaced in order to evaluate the kinematic properties of a proposed, symmetric 5-bar leg design using a torsional spring located at the hip. This 5-bar SLIP model is analyzed using a basin of attraction analyses to determine the optimal configuration for running at different velocities and further contribute to the understanding of this particular limb specialization. Additionally, an evaluation of dynamic scaling for prototyping of legged robotic systems was performed, specifically regarding the stresses and strains experienced by the symmetric 5-bar leg design.

I wish to acknowledge the mentorship of Jason L Pusey in ARL's Vehicle Technology Directorate.

Determination of Environmental Fate and Transport Properties of Energetic Materials

Blaudeau, Lauren

Aqueous solubility, the soil sorption constant (K_{oc}), and the octanol/water partition coefficient (K_{ow}) are experimentally determined constants that are the parameters for fate and transport models. These models are used to predict a compound's environmental fate. Concerns addressed by the models include what reactions a compound will undergo (decomposition, hydrolysis, photolysis), whether it will leach into groundwater or remain in the soil, and whether it will bioaccumulate in fatty systems. Five energetic compounds, all considered insensitive as TNT and RDX but potentially less environmentally harmful, were considered in this study.

In addition to these 3 constants, differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA) traces were obtained. From the DSC traces, the melting point and/or the decomposition temperature were determined. Vapor pressure and the heat of vaporization were estimated from the TGA traces. Infrared, Raman, and ultraviolet spectra were collected for reference. Comparisons with available theoretical values indicated the values determined in the laboratory were reasonable to use in the fate and transport models.

I wish to acknowledge the mentorship of Dr Stephan Bilyk, funding; the USAEOP CQL program; and the ARL Outreach Office. I would also like to thank Dr Rose Pesce-Rodriguez for her time, talent, and guidance this summer.

Characterizing Wall Effect Forces on Quadrotors towards Performing Work on Vertical Surfaces

Block, Alexis

While there is a growing prevalence of Unmanned Aerial Vehicles (UAVs) in recent years, their capabilities have not improved much beyond surveillance or package delivery. To truly use the full capabilities of quadrotor vehicles, they need to interact with and learn from their environment without human intervention, rather than just being preprogrammed for a single task. Examples of this behavior include a quadrotor that would be able to clean windows without breaking the glass, or that could use a tool to drill a hole or secure a package to a wall. These cases require the quadrotor to gauge the structural integrity of the material, know how much force their action would require, and produce counteractive torques to perform the action. To perform these actions, a quadrotor must understand the surrounding environmental forces. The goal of this project is to characterize the aerodynamic wall effects on a quadrotor system as it approaches a vertical surface, working towards the development of a control system to counteract these effects, and further determine the necessary actions of the system to compensate the forces/torques created from flying in close proximity and performing tasks on a wall.

I wish to acknowledge the mentorship of Jim Dotterweich.

Noise Stimulation in a Simulated Shooting Paradigm

Blount, Christopher

Stochastic resonance (SR) describes a phenomenon in which introducing noise into a nonlinear system improves the output signal quality. Modern research using this concept in biological systems suggests that application of broadband white noise will achieve a SR-like effect, increasing sensorimotor performance. Prior work employing noise stimulation has found that subjects exhibit an inverted "U" shaped response in terms of noise amplitudes and task performance. I hypothesized that the inverted "U" phenomena would be evident in a simulated shooting protocol for subsensory noise stimulation. Furthermore, I expected an optimum noise level at the peak of the inverted "U" would enhance trigger finger steadiness. To achieve this, randomized levels of broadband white vibrotactile noise were applied to participants during the performance of a ramp-and-hold force stability task. The vibration was introduced to the superficial aspect of the anterior forearm proximal to the elbow to stimulate the muscles responsible for the trigger pull action. In the current protocol, optimal noise levels were identified and yielded a significant increase in force stability compared to the placebo ($p = 0.0396$, $M_{A-B}=0.137$). This protocol can be used for future basic and applied research examining how sensory noise stimulation may be used to enhance marksmanship.

I wish to acknowledge the mentorship of Dr Matthew Tenan and Dr Courtney Webster. Their expertise and guidance helped to make my fellowship experience successful.

Visualizing Ferret Brain Neural Pathways to Understand Mechanisms of Blast Brain Injury

Bodt, Skylar

Protective equipment enables Soldiers to survive otherwise lethal blast events. Traumatic Brain Injury (TBI) has gained increased attention for its prevalence in Soldiers and association with subsequent psychiatric morbidity. A challenge is understanding how TBI occurs from blast exposure. Animals are used as a surrogates for humans in experiments, as the exposure be controlled and physiological outcomes measured. A recent experimental effort used the ferret to model brain injury. The ferret brain is similar to the human brain in its overall composition; however, the details of the neuroanatomy have not been fully determined. Visualization of a ferret brain can help researchers understand its structure and function as a model for the human brain. The ferret was exposed to blast, and then brain sections were stained to highlight neural pathways. The primary result of this work is dorsal, lateral, and ventral ferret brain illustrations, and diagrams explaining how brain sections were sliced and could be represented to assemble a 3D model of the complete ferret brain. Future work would include studying the direction of neuron pathways and incorporating this into a 3D model. This research begins the construction of a ferret brain atlas that can be used to advance research in TBI.

I wish to acknowledge the mentorship of Autumn Kulaga and Karin Rafaels.

A Systematic Study of the Electrical Properties of Ballistics Gelatin

Burke, Benjamin

Electroencephalography (EEG) is the process of measuring and recording brain activity via electrical activity at the scalp. One method for testing EEG devices is through using phantom devices with an embedded electrical source, but there is no standardized, low-cost phantom available. We propose the use of ballistics gelatin with added NaCl to develop a phantom head that mirrors the electrical and mechanical properties of the human head. The electrical properties of gelatin being examined have not yet been systematically studied. We altered the density and salt concentration in the gelatin to characterize changes in resistance and conductance for emulating the electrical properties of human tissue. Results show that increasing gelatin density correlates to increased resistance at low frequencies, but not high frequencies, and had no effect on conductance. Increased salt concentration led to decreased resistance and increased conductance, interacting with changes in density. The results indicate that ballistics gelatin can be used to develop a realistic, low-cost phantom head, and that changing density and salinity can alter its electrical properties. These results also indicate that the aforementioned electrical and mechanical properties are independently influenced by different variables often interacting with each other.

I wish to acknowledge the mentorship of Drs W David Hairston and Alfred Yu.

Bandwidth Enhancement of Low Frequency Networking for Infrastructure-poor Environments

Choi, Jihun

Low frequencies (3 MHz–300 MHz) have been used in various military applications, such as tactical army reliable network in complex environments and maritime mobile long-range radio communications. At these frequency bands, compact mobile communication applications, however, are limited mainly because of the large antenna size required. Recently, we developed highly miniaturized low-frequency antennas having much higher efficiency compared to similar-sized antennas, yet their narrow bandwidths reduce the extent of the communication applications. In order to significantly improve the bandwidth without increasing the antenna size, a non-Foster impedance matching technique is pursued. Since the aforementioned small antenna has a high reactance variation with frequency, it is difficult to broaden its bandwidth via conventional passive matching techniques. To address this challenge, non-Foster reactive elements must be introduced to ameliorate the variation of the antenna reactance with frequency. This technique enables low-power, highly reliable communication applications requiring wider bandwidth such as high-resolution, through-wall imaging and real-time video streaming with autonomous agents deployed in infrastructure-poor environments (e.g., dense urban, caves, tunnels, etc.) where existing technologies are not applicable.

I wish to acknowledge the mentorship of Dr Brian Sadler and Dr Fikadu Dagefu for the strong support during the summer internship.

The Effect of Cognitive Fatigue on Heart Rate Variability in a Marksmanship Performance Study

Cohen, Valerie

Mental fatigue can be characterized by subjective feelings of tiredness and has been shown to decrease physical performance during subsequent full-body exercise. The purpose of this study was to examine the effect of a cognitive fatigue intervention relative to a control on marksmanship performance. More specifically, the intention was to determine whether cognitive fatigue could be indexed with heartrate variability (HRV). Twenty Soldiers were equipped with a wireless electrocardiogram (ECG). In a repeated measures design, Soldiers completed a cognitive fatigue (response inhibition task) and control (neutral video) intervention. ECG was recorded throughout each intervention, and the last 5 min was analyzed using the standard deviation of all NN intervals (SDNN). Although not statistically significant, preliminary results revealed an increase in HRV in the control intervention relative to the cognitive fatigue intervention. Conversely, the cognitive fatigue intervention seemed to significantly ($p < .001$) increase the errors of commission during the marksmanship task. Knowledge gained from understanding the inverse relationship between HRV and cognitive fatigue can be used to aid in biofeedback wearable technology.

I wish to acknowledge the mentorship of James Head and Matthew Tenan.

Data Modeling from MUVES – S2

Davis, Danielle

MUVES-S2 is a software suite that simulates the effects of munitions on military systems, otherwise known as vulnerability/lethality analyses. Physics-based algorithms are implemented in MUVES-S2 to provide the probability of damage to a particular component, subsystem, and system given a hit by different types of munitions. In this report, the input and output information is categorized for the various types of MUVES-S2 analyses. The goal was to be able to easily harvest related information between each of the different types of MUVES-S2 analyses. Using data modeling Unified Modeling Language, a schema has been developed to visualize the MUVES-S2 inputs and output methods. Detailed usage requirements are provided for a user in order to be able to access information in the schema in to expedite the analyses process.

I would like to acknowledge the mentorship of Geoffrey Sauerborn.

Using Cardiovascular Features to Classify State Changes during Cooperation in a Simulated Bomb Defusal Task

Dennison, Mark

Teams of 2 individuals worked together in a high-intensity simulated bomb diffusing task. Half the teams were given icebreaker social time to increase comfort and familiarity with each other, and the remaining half of the teams served as controls and did not meet until the task began. Electrocardiography and impedance cardiography were recorded to examine cardiac changes during task cooperation. Changes in ventricular contractility showed that individuals who had taken part in the icebreaker showed increased task engagement over time, whereas controls showed the opposite. Data also trended to show that icebreaker subjects were in a challenge state and controls were in a threat state during the final 30 s of bomb defusion. Finally, we show that a set of cardiac features can be used to classify subject data as belonging to the icebreaker or control groups with an accuracy as high as 88%.

I wish to acknowledge the mentorship of Pete Khooshabeh, Tony Passaro, Andre Harrison, Stefan Scherer, and Cathy Neubauer.

Determining Experimental Parameters for Measurement of Localization Ability

Domanico, Morgan

Many aspects of the auditory situation awareness provided by Tactical Communication and Protection Systems (TCAPS) have standardized measurement methods; the exception is auditory localization ability. Two methods have been proposed to measure the localization ability provided by TCAPS. Method 1 specifies a horizontal array of 4 pairs of loudspeakers placed at 90° increments, with the subject seated in the center facing either 0° or 45° orientation. Method 2 specifies a horizontal array of 36 equally spaced loudspeakers. Two experiments were designed to specify the best test condition. Experiment 1 determines the ideal spacing of the loudspeaker pairs in Method 1 and measures performance for pairs spaced at 8°, 10°, and 12°. Experiment 2 characterizes the difference in measurement information obtained from Method 1 and Method 2. Student contribution included writing sections of the protocol, operating equipment, testing participants, and presenting data.

I wish to acknowledge the mentorship of Dr Angelique Scharine and Dr Nancy Vause. This research was supported in part by an appointment to the Student Research Participation Program at the US Army Research Laboratory (ARL) with the Army Public Health Center (APHC) (Provisional), administered by the Oak Ridge Institute for Science and Education through an interagency agreement between the US Department of Energy, ARL, and APHC (Provisional).

Performant Caching of Ray-Tracing Prep Data Structures

Engbert, Jonathan

BRL-CAD is an open-source computer-aided design (CAD) system developed by the US Army Research Laboratory for use during development and evaluation of military equipment, particularly for vulnerability and lethality (V/L) analyses, including ballistic impact simulations and evaluation of radar signatures.

These V/L analyses make extensive use of BRL-CAD's ray tracer. Before evaluating ray intersections, preliminary calculations are executed for each geometric object in the evaluation. This process is currently repeated before initiating any evaluation or rendering of a target model; however, the results may be suitable for caching whereby the data is computed once, serialized to a platform-independent storage format, and reused for subsequent invocations of the ray tracer.

This project's objective was to implement and evaluate a caching system for the preliminary data of each of BRL-CAD's geometric primitives. Measurements taken during this project indicate that this caching method provides very significant time savings (better than an order of magnitude on NURBS-based models that are often used for analyses). Additionally, this project has shown that caching provides a benefit for nearly all BRL-CAD primitives, indicating that a generalized caching system and API are appropriate. This project will also examine the efficacy of caching the variety of primitive-specific data structures using a single generalized implementation.

I wish to acknowledge the mentorship of Mr Geoffrey Sauerborn and Mr Sean Morrison.

A Comparison of Ultrasonic Based Spatially Distributed In-Situ Sensors to Visual Crack Measurement

Eure, Amber

A current nondestructive evaluation technique uses a signal generated by piezoelectric actuators in a pitch–catch method to detect fatigue crack growth to prevent catastrophic failure. Compared to other nondestructive inspection techniques that may not offer real-time inspection capabilities, this technique offers reduced maintenance cost and weight savings. The objective is to analyze visual crack growth data and compare the visual crack growth information to structural health monitoring (SHM) output at different frequencies. In this experiment, Aluminum 7075-T6 dogbones, with a nominal thickness of 0.063 inch, ultimate strength of 75 ksi, yield stress of 69.9 ksi, and a modulus of elasticity of 10,400 ksi with a 10-mil notch for initial crack growth, are placed in the mechanical testing system under a cyclic motion to propagate a crack. During the experiment, pictures will be taken of the crack growth and analyzed by using a MATLAB script. Fatigue testing was performed to validate the SHM capabilities of the piezoelectric sensors. The coupons were tested in 500-cycle increments under tension with a maximum load of 5 kN and a minimum load of 500 N, with data taken until failure. The pitch–catch damage index gives good correlation in comparison to the visual crack growth provided by the camera.

I wish to acknowledge the mentorship of Natasha Bradley.

Effectiveness of Commercial Radar in Airborne Applications

Fox, Maxine

A commercial radar designed for the automotive industry was tested for effectiveness in airborne applications. Analysis software was written to integrate radar, GPS, and video data streams. Visualization software was written to enable the user to gain insights into which features were detected by the radar.

Two different scenarios highlighting alternate uses of the radar were investigated. In the first scenario, the radar was flown aboard a US Army Blackhawk helicopter. Point clouds were generated that illustrated the detectability of obstacles, such as trees, wires, and fences, that might endanger the helicopter.

In the second scenario, the radar was used to track an unmanned aerial vehicle (UAV). Algorithms to detect the UAV and visualize the tracking performance of the radar were investigated. The results assisted in evaluating the effectiveness of the radar as a potential low-cost platform for monitoring airborne targets.

I wish to acknowledge the mentorship of Jerry Silvious.

Optimization and Characterization of Gold Binding Peptides Displayed on the Cell Surface of *E. coli*

Fu, Adele

In biotechnological research, the ability to control living organisms at the molecular level has garnered interest in studying and exploiting the interactions between the building blocks of biological macromolecules and organic, inorganic, and synthetic compounds for multiscale fabrication. The eCPX bacterial display scaffold has been repeatedly used to display peptides on the cell surface of *E. coli* bacteria for the discovery of affinity reagents that bind biological materials, such as protective antigen of *Bacillus anthracis*, a credible threat to the US Army. More recently, this capability has been extended to abiotic materials, such as aluminum alloy. Since gold is widely used in the technological and research worlds, there is interest in the discovery and characterization of gold-binding peptides. We have engineered *E. coli* cells with the ability to bind gold by incorporating discovered gold-binding peptides into the eCPX cell display scaffold, in order to compare their affinity and selectivity for gold and to investigate reversibility of binding. To compare the peptides effectively requires troubleshooting of observed background binding of the *E. coli* cells and/or eCPX scaffold to the gold surface by investigating various binding and wash conditions, and investigating the effects of different linker sequences for their ability to improve peptide display or create biases and artifacts.

I wish to acknowledge the mentorship of Ms Deborah Ann Sarkes, the advising of Dr Dimitra Stratis-Cullum, and the help of Dr Jeffrey Rice.

Phase Change Material as Passive Cooling System for Pulsed Power Application

Gonzalez-Niño, David

A number of Army electronic systems experience thermal transients during operation, and they require a package that can handle these peak thermal loads. Managing peak loads in the time scale of milliseconds can result in an overdesigned package requiring extra size, weight, and power (SWaP). The use of phase change materials (PCMs) in transient applications have been shown to be able to suppress hot spots or thermal peaks due to the latent energy absorption during the phase change process, resulting in improved SWaP. An organic PCM (Erythritol) and 4 metallic PCMs (Field's metal, Bi/Pb/Sn/In and Bi/Pb, Bi/Pb/Sn) have been selected for evaluation as potential replacement to the dielectric gel encapsulant currently used by ARL.

As a tool for guiding the investigation, a unidimensional, simple model was developed to study potential PCMs under different conditions. Furhtermore, this model was used to confirm the trade-off resulting from using PCMs with high thermal conductivity and low latent heat of fusion (i.e. Bi/Pb/Sn/In) versus a PCM with high latent heat of fusion and low thermal conductivity (i.e. Erythritol), as a function of the time scale of the application. From the simulation results, using the developed model, an experiment and test-bed were designed to further the understanding of of PCMs in pulsed applications.

I wish to acknowledge the mentorship of Dimeji Ibitayo, for the great opportunity to work at ARL and for his great mentorship. I would also like to thank Dr Pedro O. Quintero, Dr Lauren M Boteler, Nick R Jankowski, and Bruce Geil.

Relationship between Life Events, Self-Efficacy, and Stress Response

Harper, Samantha

The current study investigated predictors of cognitive resilience under stress. A shock or vibration was administered when an error occurred; shock was used to induce stress. We administered the Life Events Form-I (LE-I), Situational Self Efficacy Scale (SSE), and Multiple Affect Adjective Checklist-Revised (MAACL-R) to examine the relationship between preexisting stress that subjects were experiencing unrelated to the study, their confidence in their ability to do well in the upcoming task, and their stress during the experiment. There were significant negative correlations for SSE and pre-hostility and dysphoria, and a positive correlation for SSE and pre-positive affect. MAACL-R scores were also examined to determine if there was a significant difference from pre- to post-sessions (how subjects felt during the scenario). In the shock and vibrate conditions, hostility significantly increased, while positive affect significantly decreased. There was a significant increase in dysphoria from pre- and post-sessions for the shock condition only. These findings demonstrate that reported confidence was related to hostility and positive affect pre-session. Changes in MAACL-R scores support previous findings that shock induces more stress than vibration, and that participants were engaged in the task. Further investigation of these data is needed to fully understand the effects of the stress on the performance.

I wish to acknowledge the mentorship of Debbie Patton and Katherine Gamble.

Tribochemical Analysis of Wear Tracks of Silicon Nitride on C64 Steel

Harris, Michael D.

Different tribochemical reactions can occur between dissimilar materials under various contact conditions that result in radically different friction and wear behavior. At high sliding speeds, between 1.5 and 16 m/s, steel and silicon nitride contacts transition to a low-friction, low-wear regime, the origin of which is still unknown. This study used laser scanning microscopy (LSM) and Raman spectroscopy of wear tracks to understand tribochemical properties of a silicon nitride on C64 steel ball-on-disc system in dry contact. Measurements of specimens at 16 m/s sliding speed discovered an oxide film in the wear track that displayed plastic flow, whereas measurements of specimens at 1.5 m/s revealed incoherent oxide deposits within the wear region. The propensity of this tribofilm to form may relate to an increase in temperature, known as the "flash temperature," occuring at the contact region. The Raman spectra of this tribofilm suggests that it contains cobalt iron oxide, and LSM measurements observed trends in wear volume with sliding speed and time. This presentation reports on the wear volume, tribochemical phase information, and an estimation of the flash temperature for analysis of the tribofilm and its impact on the wear behavior of this dissimilar system.

I wish to acknowledge the mentorship of Dr Stephen Berkebile, and the assistance of Nikhil Murthy and the rest of the Drives team. I would also like to acknowledge Dr Thomas Scharf and Dr Samir Aouadi, from the University of North Texas, for their support in classsifying Raman spectra.

Improving Depth Perception at long range

Hawkins III, Howard

Determining relative distance to a target as seen from the military gunner's perspective is a difficult task. Humans use numerous visual cues to perceive depth, which are typically grouped as monocular or binocular. Monocular and binocular depth cues are used to assist with depth perception, which becomes a difficult task as the targets exceed distances greater than 1,500 meters. In order to gain knowledge of Army weapon systems, interviews were conducted with current and former US Army Soldiers pertaining to depth perception, targeting, and issues with current weapon systems. A literature review was also conducted to guide efforts to design a depth perception experiment. This research focused on determining how effective gunners are at depth perception on the battlefield. Models were created in Virtual Battle Space 3 by placing targets at different distances and orientations to be used for experimentation. The ultimate goal of this experiment is to see if the correct distance and orientation of targets can be identified by study participants. The data will be collected and an analysis will be performed.

I wish to acknowledge the mentorship of Dr Thomas Davis and Jared Sapp.

The Bradley Fighting Vehicle Airburst Munitions at Long Range

Heim, Isaac

In an attempt to better the target acquisition system and firing techniques of a Bradley Fighting Vehicle using airburst rounds, a literature review was conducted. A detailed look at depth perception increased the understanding of how well targets are identified and how well their orientation on the landscape is understood. The manual version of target acquisition (using mils), aided target acquisition, and the automatic target acquisition were then compared to each other. After running trials with the current system, it will be decided if an increase in automated functions is needed to bridge the targeting gap where normal sensors fall short. Therefore, a preemptive look into advanced technologies such as next generation thermal sights, scanning laser range finders, unmanned aerial vehicles, and automated target recognition were examined as potential methods for target acquisition and compared to the current Bradley Fighting Vehicle capabilities.

I wish to acknowledge the mentorship of Dr Thomas Davis, Jared Sapp, and Jonathan Crutcher.

“Can I Call You Fido?”: Exploring Affect in Human Robot Communication in a Collaborative Environment

Henry, Cassidy

Demand for intelligent and autonomous systems is on the rise in both the Army and greater society. As a result, research to develop capable systems is crucial. A huge part of how humans express and interpret information is linguistic, and replication of these innate faculties is a challenge in artificial intelligence. While research relevant to this challenge is ongoing, our work seeks to address the under-examined area of sociolinguistic interaction with robots and its effects on performance in human-robot teaming tasks. Within a Wizard of Oz experimental design, audio recordings were collected for 10 participants using spoken language in a collaborative search and navigation task with a robot teammate. Counts of lexical patterns of social behavior were performed, as measures of paralinguistic indicators of affectual states, and compared to performance on the task. Results suggest a possible relationship between personal modes of address and performance, indicating a potential benefit from positive social interaction with a robot teammate. Moving forward, we will collect data from more participants and perform additional analyses, including employing other affect measures (prosody, intonation, etc.), examining other outcome variables (trust, perception, etc.), and controlling for more covariates (such as spatial ability) to further refine the results.

I wish to acknowledge the mentorship of Dr Kim Pollard and Dr Matthew Marge at ARL, and additionally Dr David Traum and Dr Ron Artstein at the USC Institute for Creative Technologies for their input and assistance, all of the collaborators on the Bot Language project, and my linguistics family at the UCLA Department of Linguistics (especially Brice Roberts, for helping me learn intonational phonology, which is part of further research).

Whirl Flutter and Drag Simulation

Hoover, Christian

The XV-15 tilt rotor has the ability to land and take off vertically as a helicopter, and cruise as an airplane. By combining these separate modes, the best—and worst—of both are present. One design challenge for tilt rotor aircraft is known as whirl flutter. Whirl flutter is the dynamic destabilizing coupling of wing and rotor motions. This destabilizing effect limits the forward speed of propeller-driven aircraft, and, in particular, aircraft with large proprotors like the XV-15. Whirl flutter has been analyzed experimentally and with multibody dynamics tools, but with the advance of computational power and High Performance Computing, higher fidelity simulations can be developed. The objective of the current project is to develop a coupled multibody dynamics and computational fluid dynamics (CFD) model to analyze whirl flutter on a high performance computing platform. The XV-15 model blade geometry was created from a multibody dynamics code description of the blade. CFD models of the rotor blades and wing were also developed. The rotor was analyzed with both rigid and elastic blades with and without the presence of the wing. The cases are being evaluated and compared to experimental data.

I wish to acknowledge the mentorship of Drs Matt Floros and Hao Kang.

Simulations and Computer Based Applications for Training

Jackson, Zachary

Simulations and computer-based training continue to dominate the learning and classroom environment. Current simulations and training rarely capture the genuine experience of being in a non-forgiving environment. I worked on 3 projects—DisasterSim, Python script, and vehicle movement in Unity. My first project was to create a disaster relief simulation scenario of an earthquake centered in Quezon City, Philippines, and an earthquake in Los Angeles. I chose Quezon City, Philippines, for the high population and the new Partnership For Growth (PFG) contract with the US that was made to improve economic growth and development in the Philippines. In the field, people are not congratulated for excelling; however, people are punished for doing the incorrect task. The aim was to make a scenario that reflects this. During my second project, I worked with Ryan Spicer on developing a Python script that would improve the point cloud processing time of LAS point clouds in PhotoScan. I am currently working on the One World Terrain project experimenting with vehicle movement in the Unity Engine using a third-party NavMesh system. We currently have infantry Soldiers in the environment and the goal is to include military vehicles.

I wish to acknowledge the mentorship of Ryan McAlinden and Ryan Spicer.

Automating the Analysis of Laser-Induced Shock Waves

Johnson, Tache

By examining the effect of chemical reactions on laser-induced shockwaves, my mentor, Dr Gottfried, developed a laser-based technique for estimating the performance of energetic materials. The overall goal of this project was to automate the shock detection process by creating a MATLAB program. A series of sample images was used to find a way to automate the shock detection process. The relevant MATLAB functions include edge detection, image contrast, and data charts. The first step of this project was to automatically track a laser-induced shockwave (based on high-speed video) using the edge detection sequence in MATLAB. An existing shockwave detection graphical user interface (GUI), developed in 2005 by Dr Michael J Hargather (Penn State University), for automatic tracking of shockwaves from explosive events was adapted for the current application. The enhancements I tested and applied to the MATLAB program will enable faster and more accurate data analysis of the laser-induced shock waves by eliminating the tedious task of manually analyzing 20+ pictures one-by-one. Ongoing work includes enhancing the image data for optimal shock detection, redesigning the entire GUI, and creating a secondary window with new settings.

I wish to acknowledge the mentorship of Dr Jennifer Gottfried, and the aid of Dr Steven Dean and Dr Eric Collins for their support and guidance during the internship. I would like to thank the Thurgood Marshall College Fund for accepting me into their internship program.

Standard Methods for Performance Characterization of Peptide-based Biorecognition Reagents

Jones, Curtis

A major challenge in the development of robust biosensors lies within the limitations of using monoclonal antibodies, the current industry standard, as biorecognition elements. While these antibodies tend to exhibit high affinities and selectivities for targets of interest, their poor chemical and thermal stabilities, and extensive discovery and manufacturing processes, make antibodies ineffective as on-demand reagents for biodetection outside of controlled environments. Conversely, peptide-based reagents, such as those discovered through the Protein Catalyzed Capture method, are promising alternatives to antibodies due to their extreme stabilities and ease of scale-up. In order to characterize these newly discovered peptide-based antibody alternatives in a rapid and effective way, standard methods must be established. This work describes methods to determine the binding kinetics and selectivity of peptide reagents using a Biacore T200 surface plasmon resonance instrument and the multiplex Luminex 200 platform, respectively. All procedures were optimized using streptavidin and an anti-streptavidin peptide (AWRHPQGG) as a model system. These standard operating procedures will be essential for the understanding of new and emerging peptide biosensing reagents.

I wish to acknowledge the mentorship of Dr Matthew Coppock for the opportunity to assist him in his research at ARL, and for all his guidance in a scientific research environment. I would also like to acknowledge the entire Biomaterials team for the advice that has been given to me during my research.

Classifying Captioned Images for Anomaly Determination

Levis, Joel

We conducted research to assess the impact of supplemental natural language keywords on the efficiency of deep learning image classification algorithms in the domain of anomaly determination from crowd images. A collection of crowd images—determined to have equal distribution between benign and malicious activities—was obtained through Google Images. As a baseline classifier, the AlexNet Neural Network was fine-tuned to enhance image classification capability without using natural language keyword considerations. A classification accuracy of 81% was achieved. Amazon's Mechanical Turk system was then used to gather noun keywords corresponding to each image. After analyzing these keywords to build a model of association, 5 nouns were found to be of high frequency in images of malicious crowd activity. Classifiers for each of these nouns are currently being trained, and a 6-stream neural network will be built to combine the output of these classifiers and the baseline classifier to improve classification accuracy. It is hypothesized that the inclusion of these keyword classifiers will offer improved classification accuracy compared to the accuracy of the baseline classifier alone. Positive results of this research of this will serve as proof of concept for larger-scale research in the domain of social media exploitation.

I wish to acknowledge the mentorship of Mr Michael Kolodny, Dr James Michaelis, and Dr Heesung Kwon. Also, I wish to acknowledge Mr Sungmin Eum and Dr Hyungtae Lee for their technical guidance.

Characterization of Structural Damage using Magnetostrictive Embedded Composites

Long, Nicolas

The ultimate goal of this experiment is to determine the state of material damage using magnetic measurements for the benefit of structural health monitoring. In this study, it was observed that magnetostrictive material embedded in composites produces irreversible changes in magnetic flux and magnetization intensity when undergoing cyclic loading, which are monitored using an induction coil sensor. The magnetostrictive material used is Terfernol-D particles embedded between layers of pre-preg AS4/3501-6. Changes in the magnetic flux can occur during the earliest onset of damage (e.g., crack nucleation, fiber breakage) until complete failure. For airframe structures, this method of structural health monitoring has the potential to change current methods of structural inspection and maintenance methods used on Army platforms. Experimental data was obtained from this study based on a series of fatigue tests performed on magnetostrictive embedded composite specimens. The change in magnetic flux density as a function of fatigue load cycles is studied.

I wish to acknowledge the mentorship of Mr Michael Coatney and Dr Mulugeta Haile, and the support of Drs Jin Yoo and Asha Hall.

The Use of Eye Metrics to Index Cognitive Workload in Video Games

Mallick, Rohit

Eye-tracking metrics are known to provide unobtrusive measures of cognitive states, such as workload and fatigue, and can serve as useful inputs into human computer interfaces. To further explore the usefulness of eye-tracking for the estimation of cognitive state, the current experiment evaluated saccade, fixation, and pupil-based measures to identify which metric provided the highest index of cognitive workload in a dynamic unconstrained task (Tetris). Our results show that some eye movement features are correlated with changes in workload, manipulated via task difficulty. Among these were blink duration, saccade velocity, and tonic pupil dilation.

I wish to acknowledge the mentorship of Dr Brent Lance, as well as Dr Jon Touryan, Dr Anthony J Ries, and Mr David Slayback.

The Blacksmith's Paradox

Mansour, Emily

The Blacksmith's Paradox is the apparent transient transfer of heat through metals and alloys that does not obey the laws of classical physics—in this case in wrought iron and steel. This is said to occur when a hot end of a metal object is quenched, and explanations for the sensation in the paradox have never been fully determined. Although very little is known about the phenomenon, there are some apparent required conditions: steel (ferrous alloy), heating of one end of the bar resulting in a large temperature gradient, and the rapid quenching of the hot end. In this study, we designed an experiment setup using high-speed infrared cameras and thermocouples to replicate the heating and cooling conditions of the paradox for metallic bars. Temperature measurements were taken in a heated and quenched metallic bars as a function of time and position to determine the possible existence of the Blacksmith's Paradox. Preliminary results show that the temperature rise in gray cast iron is about 5 times higher than predicted in thermodynamic models. This research is significant, because the classical laws of thermal conduction should not allow the Blacksmith's Paradox.

I wish to acknowledge the mentorship of Dr Mulugeta Haile and Dr Robert Pond.

Developing a Statistical Model to Guide Development of Synthetic Tissues with Realistic Mechanical Properties

McGee, Ja'Nae

In the military, realistic, simulation-based training is employed to teach Soldiers critical skills necessary to succeed on the battlefield. Medical interventions are commonly taught to alleviate medical emergencies that arise while in the field. Currently, synthetic simulated tissues are used in medical trainers to teach these procedures, but the fidelity of these tissues is lacking. One of the leading causes of preventable death is a collapsed lung, or tension pneumothorax, which is treated using a medical procedure that is currently being explored at the Medical Simulation and Performance Branch (MSPB) of the ARL-HRED's Advanced Training and Simulation Division (ATSD). To create synthetic tissues that have similar properties to real human pleura, a critical tissue breached for the treatment of a tension pneumothorax, research is being done to compare current synthetic simulators to human tissue. At the MSBP, the engineers perform basic research analyzing the mechanical qualities and properties of human pleura and synthetic pleura. In order to test the synthetic pleura, uniaxial and biaxial testing is done to find the strain energy density, ultimate tensile strength, and failure strain. The end goal of collecting this data is to create a statistical model that gives simulated tissue manufactures a general range in which the newly created synthetic tissues' stress stretch curves should fall.

I wish to acknowledge the mentorship of Kurtis Palata, Mark Mazzeo, and Beth Pettitt.

CLIVE—The Customizable Lighting Interface for Visualization of EEG Signals: Arduino Processing and Physical Design

Miller, Joshua R.

Electroencephalography (EEG) is a neuroimaging method that allows researchers to measure the electrical activity of neurons using electrodes placed on the scalp. However, EEG activity is difficult to interpret by a general, non-expert audience, especially with large numbers of electrodes. Customizable Lighting Interface for Visualization of EEG Signals (CLIVE) was designed to be a translucent head implanted with LEDs to be used as a visualization tool for EEG signals, which represents overall neural activity in different regions of the brain. In this way, CLIVE produces meaningful visualizations for non-neuroscientist audiences. An initial prototype version of CLIVE uses the wireless Emotiv EPOC+ EEG headset for data streaming, MATLAB scripts for data processing, and an Arduino Mega that, in real-time, converts the data so that it powers the LEDs in the phantom head in accordance with voltage measured from the EEG cap. Two primary aspects of this project are the physical design and Arduino processing. Physical design for this project included general lighting design, as well as 3D modeling of the plastic base, "straws" for wires within the head, and a plastic case for the Arduino and its components. The Arduino processing aspect of the project was focused primarily on how to best represent EEG signals as LED flashes or swells. In this way, the physical design and overall aesthetics were closely linked to Arduino capability.

I wish to acknowledge the mentorship of Dr W David Hairston for his continued feedback and encouragement throughout the project, Dr Alfred Yu for his guidance and help with physical design and 3D printing, Mr Wosen Wolde for his assistance with electronics design, and all those who offered their time to help with the project.

Software Development for Army Software Programs & Mobile Applications

Moore, Jaquan

Software programs and applications play a vital role in Army research, and aid in the improvement of military training. While having the opportunity to research and develop a few mobile applications, I was also simultaneously working on an Android application package (APK) generator using Gradle and Android Studio.

The APK generator was used to compile a list of APK files created by a program used in Android Studio. The program used Groovy language and the Gradle build system to generate the files. The user uses Gradle to provide properties for the program that will then generate an APK file, and all of the files included in the file will be stored and printed at the user's request. This program is used to make application development more efficient and to compress the many APK files that are created individually when creating applications.

The mobile applications created by ARL are used to aid Soldiers in training and also provide support for military personnel in their everyday lives. I was able to work with 3 of the iOS mobile applications and develop new algorithms for them. One was an informational application that provides steps and quizzes that help with assessing Soldier wounds; the other 2 applications are military games that are used for Soldier's personal entertainment.

I wish to acknowledge the mentorship of Irwin Hudson and Angel Rodriquez.

Characterization of Helmet Pads

Muller, Allison

The purpose of this study is to gain an understanding of the material properties of combat helmet pads. An understanding of the properties of the pads will help improve combat helmets to protect our Soldiers from traumatic brain injuries.

In this study, 2 types of helmet pads were examined: the Gentex Solider and Team Wendy Police helmet pads. The Gentex pads are composed of 2 different types of foams. One layer adjacent to the head is a softer foam used for comfort. The second layer adjacent to the shell of the helmet is a stiffer foam used for protection. The Team Wendy Exfil ballistic pads are composed of a single thinner layer of comfort foam. Compression tests were performed on cylindrical samples with various diameters using an Instron 1122 electromechanical machine. The samples were tested under confined and unconfined conditions. Acrylic containers were machined to fit the samples for the confined experiments. The compression tests on the Gentex pads were performed on all of the layers together, as well as each layer separately. The effects of plastic and fabric covers, and repeat loading conditions were also characterized. The data shows these different testing conditions do affect behavior of the foams.

I wish to acknowledge the mentorship of Dr Sikhanda Satapathy and Dr Mike Kleinberger. I also wish to acknowledge the Assistance of Paul Moy, Mike Zajicek, Dennis Hash, and Bobby Hall.

Characterizing the Launch of Laser-Driven Flyer Plates Using Schlieren High-Speed Imaging

Mullins, Asahel

Energetic materials are those that store chemical energy, which can be released in an exothermic reaction. Some examples of energetic materials are explosives, propellants, and fuels. In order to develop new and improved energetic materials, we need a thorough understanding of their behavior, including how they respond to external impact. One method to generate these impacts is laser-driven flyer plates. Here, the launch of laser-driven flyer plates is characterized using schlieren high-speed imaging. This method allows us to visualize the processes that occur when the focused laser pulse generates laser-induced plasma on the flyer plate assembly (FPA). The FPA consists of a borosilicate glass substrate with aluminum foil epoxied on the back surface. The plasma results in intense light emission and detachment of a mm-sized piece of aluminum foil (i.e., the laser-driven flyer plate). The detachment of the flyer plate causes hot, ejected particles to follow the flyer plate. The flyer plate accelerates away from the FPA, heating the air as it travels at supersonic speeds. Its launch and flight produce multiple strong shockwaves. The impact of the flyer plate (and the resulting debris) ultimately results in the decomposition of the impacted energetic material.

I wish to acknowledge the mentorship of Dr Jennifer L Gottfried (team leader) and for the aid of Dr Steven W Dean, Dr Govind Mallick, Dr Rose Pesce-Rodriguez, and our branch chief, Dr Niru Trivedi, for providing me with an rewarding opportunity to gain knowledge, insight, and hands-on experience within the Lethality Division at ARL. Last but not least, I would like to thank the Thurgood Marshall College Fund for their guidance and support.

Towards Autonomous Self-Righting for Robots in 3D

Neal, Barbara

US Soldiers have indicated that the robots they use sometimes unintentionally flip over in field conditions, and it can be difficult to return them to their upright orientation remotely. A universal self-righting solution to this problem is essential to retrofitting and equipping future systems. To date, ARL researchers have developed a 2D generic analysis framework, whereby any robot can maximize its own ability to self-right using whatever intrinsic hardware it has. In this effort, we work toward redesigning the software for higher degree of freedom 3D analysis while improving performance. Specifically, we focus on translating the existing code from MATLAB to C++, and changing the existing exhaustive algorithms to using the idea of white- and black-box testing solutions for efficiency. We also leverage 2 traditional motion planning techniques, Probabilistic Road Maps (PRMs) and Rapidly Exploring Random Trees (RRTs), to self-righting. We expect that this will enable future robots to be designed to self-right under a wider variety of circumstances, enhancing their usefulness to Soldiers.

I wish to acknowledge the mentorship of Chad Kessens, a robotic manipulation researcher with the US Army Research Laboratory's Autonomous Systems Division. I would also like to thank Lenora Longstreet-Haire for guiding me to this amazing opportunity.

Blast Resistant Trash Receptacle Liner

Neidenfeuhr, Travis

Trash receptacles provide an ideal way for terrorists to conceal IEDs and are often a common weak point in security. Most commercially available blast-resistant trash receptacles are costly and make replacing existing receptacles financially impractical. To quickly and efficiently design explosive-resistant liners to retrofit existing trash receptacles, a computational model was developed for analyzing the effects of geometry changes on the blast resistance of receptacle liners. Using this model, the blast mitigation capability of several candidate geometries was evaluated with 4 different sized explosives. This general framework can be used to design and evaluate the blast-resistance of more complex geometries and other explosive-structure interactions for future research.

I wish to acknowledge the mentorship of Dr Richard Becker, Dr Todd Bjerke, and Dr Jeffrey Lloyd.

Power Electronics Packaging: An Approach with Stacked Die and Integrated Cooling

Niemann, Valerie

The Army uses power devices to convert and control electrical power for a variety of applications, including electric vehicles, solar, and microgrids. State-of-the-art packaging limits power device capability due to its high parasitic inductance from the planar arrangement of devices; inefficient heat dissipation; and mechanical failure from wirebonds, direct bonded copper substrates, and large area contacts. To address these challenges, a package termed "Power Tower" has been designed for a half-bridge configuration, the building block of most power electronics modules. The design includes a stacked arrangement of devices, an integrated cooling system, and replacement of unreliable structural components with machined copper layers.

The work presented here covers the material selection, fabrication assembly, and experimental setup required to assess the performance of the Power Tower Module. A successful demonstration would indicate a significant improvement in size, weight, and power over existing power packaging technologies, including the first demonstration of a high-power package with stacked die and integrated cooling. Benefits include over an order of magnitude reduction in size and weight, lower cost, and an increase in reliability and performance. This packaging concept will move the Army closer to achieving its goals in high-power applications.

I wish to acknowledge the mentorship of Dr Lauren Boteler for providing this opportunity and excellent counsel. In addition, I wish to extend thanks to the Power Packaging Team and the Thermal Sciences and Engineering Team for supplying resources and training for this project.

Reliability Investigation of E-Mode AlGaN/GaN High Electron Mobility Transistors

Nouketcha, Franklin

As a smart material, gallium nitride (GaN) possesses piezoelectric properties, which are responsible for the formation of the 2-dimensional electron gas (2DEG) at the interface of AlGaN/GaN heterostructures. Unlike the inverted channel of traditional silicon (Si) MOSFETs, the 2DEG has simultaneously high carrier density and mobility due to the lack of dopant impurities. This allows for the fabrication of high electron mobility transistors (HEMTs), which have the potential to outperform Si devices in terms of energy efficiency, speed, high-power and high-temperature handling capability. Despite all of its attraction, however, GaN technology is not as mature as Si and SiC, and reliability needs to be established for the various alternative device architectures currently being developed to achieve normally-off (E-mode) operation. We have performed electrothermal stress measurements and analysis of 2 different device architectures, focusing mainly on threshold voltage instability, and gate-dielectric integrity. Preliminary results indicate that significant improvement of the gate-dielectric is necessary to suppress leakage current during stress. Threshold voltage instability due to bipolar and unipolar gate-bias stress is a reliability issue for devices that have insulating gate dielectrics. Future work will include a detailed investigation and analysis of key failure modes to determine the underlying physical mechanisms and provide feedback to manufactures to improve device design and processes.

I wish to acknowledge the mentorship of Dr Ron Green and the assistance of Mr Daniel Habersat, Dr Lauren Botler, and Dr Aivars Lelis.

Deposition of Silicon Oxide Thin Films with Embedded Gold Nanorods via Atmospheric Pressure Plasma Deposition

Palmeri, Joseph

Nanocomposite coatings, consisting of organic or inorganic thin films with embedded nanomaterials, have emerged as a new class of materials with unique properties suitable for a wide range of applications. Several different methods exist for the production of nanocomposite coatings, with many requiring the use of vacuum reactors. Recently, there has been interest in the use of atmospheric pressure plasma-enhanced chemical vapor deposition to produce nanocomposite coatings, notably for the production of silver nanoparticle embedded films with antimicrobial properties. In this study, a single-step fabrication of silicon oxide coatings with embedded gold nanorods via an atmospheric pressure radio-frequency (plasma deposition) process is investigated. The organosiloxane and gold nanorod precursor mixture is delivered directly into the afterglow region of the plasma discharge and can be deposited onto a number of surfaces. The gold nanorods have the ability to modify the optical properties of the thin film into which they are embedded. This single-step atmospheric pressure plasma deposition process, therefore, allows for the production of silicon oxide thin films with tunable optical properties, leading to a wide range of applications.

I wish to acknowledge the mentorship of Andres Bujanda, whose knowledge, encouragement, and suggestions were invaluable during this project. This project was also made possible through the help of several other engineers and scientists who aided in XPS, RBS, and SEM characterization.

Emotion Regulation and Coping in Infantry Soldiers

Patton, Colleen

A study was conducted recently at Ft. Benning, Georgia, to test a new approach to training Soldiers to cope with stressors. As part of this effort, a series of psychological and physiological tests were administered before and after training events, as well as for a control group. Sixty-four infantry Soldiers (arranged into squads) took part in the training study, which encompassed both virtual and live scenarios. This research addresses a small subset of the study. Sports psychologists have found that elite athletes who have high coping skills tend to have low anxiety and better emotional regulation. They suggest that this combination may allow them to focus on performance. We tested to see if the same correlation existed in Soldiers. Coping skills and stress were measured with the Revised Ways of Coping and MAACL-R questionnaires, respectively. T-tests verified that there were no differences in coping, allowing all the participants to be grouped together. Negative correlations between problem focus and anxiety, hostility, and dysphoria were found. This conclusion opens doors to future research in determining how to better Soldiers' performance increasing their PFOC and emotional regulation abilities.

I wish to acknowledge the mentorship of Samantha Napier. I would also like to thank Katherine Gamble for her guidance.

MTK StartUP

Purdie, Cydni

Since 1998, the MUVES-S2 software has been used by the Army, Navy, and Air Force (Tri-Services) to analyze weapon vulnerability and munition lethality by simulating the effects of indirect and direct-fire munitions against modeled military systems. The MUVES-S2 graphical user interface (GUI) had not been modified since the early 2000s, and the MUVES Tool Kit (MTK) is the next generation GUI for the MUVES-S2 software.

The goal of my internship was to develop training materials, videos, and presentations to introduce the new MTK to the MUVES-S2 user community. I used ActivePresenter and Audacity video- and audio-capturing software, and was able to demonstrate MTK installation as well as the basic functions of the new GUI.

My contribution to these training materials is critical for the long-term MUVES-S2 users of the Tri-Service community to understand and take advantage of the GUI improvements and advancements provided by the ARL-SLAD.

I wish to acknowledge the mentorship of Elaine Hunt and Geoffrey Sauerborn for helping me during the extent of my internship, and for the opportunity to work alongside you both.

Construction and Characterization of a Robust Plasmid for the Fluorescent Identification of fimbriated *E. coli*

Purdy, Cara

The application of synthetic biology-derived bacteria to abiotic platforms is an emerging field with many useful prospects, including "living" bio-hybrid systems. The use of synthetic consortia, or groupings of several engineered microbial populations, is one strategy to equip these systems with multiple cellular functions to fulfill complex tasks. This work has developed genetic circuitry that allows *Escherichia coli* cells to express unique bright fluorescence so that strains may be "color-coded" when mixed and, thus, individually characterized. In particular, this genetic system facilitates fluorescence along with expression of various mutants of Type 1 fimbriae. Fimbriae enable shear force-dependent binding properties that could be harnessed for conditional binding to device surfaces. A time course study revealed that TagRFP-T, a monomeric red fluorescent protein, is more effective in cell visualization than DsRED after 8 hours of induced expression, and is similar in brightness to monomeric EGFP. Additionally, the fluorescing cells showed fimbriae-mediated cell binding. Overall, these findings indicate that both EGFP and monomeric TagRFP-T coexpress well in fimbriated *E.coli* strains; their unique spectra (green and red emission, respectively) should allow for distinguishing between strains that harbor varied fimbriae mutations. By allowing both fimbriae production and cell visualization, this versatile coexpression system supports strain identification in mixed-population scenarios, especially for fimbriae-mediated surface-bound applications.

I wish to acknowledge the mentorship of Dr Jessica Terrell and Ms Deborah Sarkes for the opportunity to study under them at ARL. Recognition is also extended to Dimitra Stratis-Cullum and the Biotechnology Branch for their continued support of this project.

Range Digitization Support for the Flight Sciences Branch

Ranawake, Charith

We detailed several projects that seek to digitize manual processes in efforts to optimize numerous tasks completed by members of the Flight Sciences Branch (FSB). These manual processes include gathering shot images from the free flight spark range, analyzing downrange yaw station images, analyzing shotgun targets, and viewing reports in the FSB Digital Library database (Aerobase).

The first project addressed the automation of 2 free flight spark ranges, Aerodynamic and Transonic Experimental Facilities (AEF, TEF), by enhancing ARL's software with the integration of digital cameras. The original process required individual pieces of film to be manually collected, developed, and analyzed after each shot, which was cumbersome and laborious. The integration of digital cameras will allow the researcher to conduct and acquire data from shots in a matter of minutes as opposed to hours. The next project provided a mechanism to collect and analyze measurements from downrange yaw images containing 2 projectiles. The analysis of shotgun targets involved writing a user interface to compile data from the multiple impact sites on a target due to the firing of a shotgun shell. The final project involved writing a user interface that would provide a simple method to view reports from the Aerobase without modifying the database entries, which had previously been a problem. These enhancements will contribute to the increase of productivity in the workplace due to a more automated process for specific, repetitive tasks.

I wish to acknowledge the mentorship of Dr Sidra I Silton, for her guidance and continual support throughout the mentorship; and Mr Ilmars Celmins, for his contributions, attentiveness to details, and assistance with this project.

Embedded Sensing of Zinc Oxide Nanoparticle for Strain Monitoring

Randolph, Marquisha

Piezoelectric materials have been an essential element for strain monitoring due to their versatility for sensing and generating energy. Although many types of piezoelectric materials have been used for strain monitoring, piezoelectric thin films can be flexible and conformable. It has been shown, however, that piezoelectric thin films have lower piezoelectric response, but give greater flexibility and show more promise since they perform better under stress. Therefore, the objective of this research is to fabricate a piezoelectric zinc oxide (ZnO) nanoparticle-based thin film that has a high piezo electricity that can be tested for its mechanical properties. Zinc oxide nanoparticles varying in weight fractions ranging from 0–60% where distributed into 2 polyelectrolyte solutions. The solvent was placed into a petri dish and dried at room temperature. Once the thin film was formed, the specimens were mechanically tested for elastic modules, ultimate strength, and failure strain.

I wish to acknowledge the mentorship of Mark Bundy and Asha Hall.

Unmanned Aerial System Susceptibility

Sherfield, Sarai

Analysis of the susceptibility of commercial Unmanned Aerial Systems (UAS) to electromagnetic (EM) fields of various frequencies and modulations is an important research objective to ARL. This effort aims to determine under which conditions they remain usable and under which conditions their flight becomes erratic or unreliable. The analysis of the commercial drones consists of exposing the UAS to EM fields in a radio frequency measurement chamber (specifically, a gigahertz transverse electromagnetic cell) in order to simulate a realistic environment. This project emphasizes its focus on determining the integrity of previous tests by increasing the increments used to collect data within frequency bands in which an effect occurred. Findings verify the validity of increasing the range of frequency increments used to observe the approximate bandwidth at which flight becomes unreliable.

I wish to acknowledge the mentorship of Dr Charles Dietlein, and the advising of Mr Brian Nelson, Mr Roger Cutitta, Mr Mark Berry, and Mr Neal Tesny.

Flapping-Wing Air Vehicle Mechanism Design

Shin, Delia

Flapping-wing aerial vehicles rely on flapping action to achieve lift and thrust. An efficient method to achieve flapping action is the crank-rocker or 4-bar mechanism. Due to the breadth of vehicle sizes and designs, a generalized mathematical formulation based on Freudenstein's equation is developed to design a crank-rocker mechanism that is able to achieve an arbitrary flapping range while meeting external design constraints. The results of the proposed approach are used to highlight trends in the design solution space that lead to valid solutions. To validate the approach, a series of physical mechanism prototypes are designed and built, and integrated into a prototype flapping-wing aerial vehicle.

I wish to acknowledge the mentorship of John Gerdes. Without his direction and leadership, this project would not be possible. I will always remember his enthusiasm and passion for flying vehicles, as it is what stirred my own interest in this field.

Alignment of Filamentous Bacteria under Flow

Smith, Austin

Bacteria have a promising future as components in bioengineered devices due to the relative ease with which their genome can be manipulated. However, the binding properties of surface-bound filamentous bacteria in response to flow is an area of study that has not been extensively explored. Being able to control the behavior of these filaments under shear could prove to be extremely useful in the building and maintenance of biostructures. In this study, we examine how filamentous E. coli respond to various shear conditions, with a focus on alignment and elongation of individual cells. We find that under certain flow rates, filamentous cells align and extend with the flow under multiple growth cycles. The greatest challenge in keeping cells aligned with flow is overcoming a buckling behavior caused by natural growth of the cell. By adjusting the viscosity of the flow solution, we are able to control the shear conditions applied to individual cells in order to overcome the buckling of the cell. In finding a set of conditions that foster growth of straight filaments, we gain greater insight into controlling the shape of the cells for use in bioengineered devices.

I wish to acknowledge the mentorship of Dr Justin P Jahnke and Dr Xuanhong Cheng for their advice and aid in conducting research. I also wish to thank the Biotechnology Branch and Biomaterials Team at ARL for continued guidance and input.

Using Open Source Software to Remotely Control a Quadcopter from a Computer

Smith Jr, Duane

Robot Operating System (ROS) is an open-source platform consisting of various tools and libraries to create a wide range of robotic projects. After learning this software in order to know how to communicate with the quadcopter, I started using ROS to communicate with the Bitcraze Crazyflie 2.0 using a controller and a computer. The Crazyflie 2.0 is a flying open development platform that can be adapted to build more complex and larger drones. Using the Crazyflie, I created a larger quadcopter by building a frame around the main component of the Crazyflie. Next, I flashed the Crazyflie with a firmware update that would make it compatible with the 4 brushless motors for the big quadcopter. With additional components such as a 12-V battery, big quad deck, power distribution board, prototyping expansion board, 4 electronic speed controllers, and a lot of soldering, I was able to successfully get the computer to communicate with the big quadcopter. Further research and development will allow quadcopters to follow Soldiers into combat for surveillance.

I wish to acknowledge the mentorship of Thai Phan, Ryan Spicer, and Rhys Yahata. In addition, I thank all of the staff at ICT and the MxR Lab for all of their help and support in making this internship experience memorable.

A Seamless Bidirectional Head-Mounted Tactile Display with Multithreading

Tobechi II, Akili

One of the biggest challenges in the successful development of a head-mounted tactile display (HMTD) is a seamless bidirectional wireless communication. This feature is a must-have, as it allows team members to communicate without requiring a physical switch between listening and talking. The current implementation that uses TCP/IP client-server networking protocol to communicate between multiple HMTD systems has some limitations. Switching between client mode (talking) and server mode (listening) requires user intervention to close the socket and restart the program. This process makes the bidirectional communication cumbersome and not seamless. Therefore, my effort was to remove that barrier and allow easier communication among a cluster of HMTD systems. To address this issue, I proposed and implemented TCP/IP multithreading, a computing concept that allows different jobs or code to run in near parallel. Theoretically, multithreading would allow client and server code to run together, eliminating the need to physically switch between the 2 modes. Using this approach, the HMTD system would be able to send and receive messages bidirectionally and seamlessly.

I wish to acknowledge the mentorship of David Chhan and Dr Kim Myles.

Data Analysis for the Biomechanics of Staircase Ascent Study

Towner, Armoni

This project is the analysis of biomechanical data collected during a study of staircase ascent. The results can be used to help with the design of equipment such as exoskeletons or prosthetics. In this study, 20 male Soldiers were equipped with 3 different loads: baseline (no additional load), ideal (33.4 kg), and heavy (58.4 kg), to carry up the staircase. While going up the stairs, the Soldier's movement was tracked by motion capture cameras that followed markers placed on his right leg and foot. A force plate was located underneath the third step of the staircase. The force plate and marker position data were used to calculate the ground reaction forces and the joint forces, angles, and moments. I hypothesized that as the loads increased, there would be increases in ground reaction forces, joint forces, joint angles and joint moments during staircase ascent. The data were analyzed using SPSS version 22. The tests that were run on the data were a repeated measures analysis of variance and a Tukey post hoc test to determine if the data had a statistically significant difference.

I wish to acknowledge the mentorship of Dr Philip Crowell for the chance to conduct research at ARL and for his continuous help.

Characterization of Early-stage Fatigue Damage in CFRPs using Active Thermography

Wallace, Micheal

Structural damage is preceded by several, often simultaneous, changes in the microstructure of the constituent material. For instance, fatigue crack formation is preceded by crazing, shear-slip banding, dislocation tangles, microcrack formation, or increase in Martensite volume fraction (in steel) and other surface and subsurface changes. In general, most of these changes are not detectable using existing structural health monitoring (or SHM) techniques, as most SHM sensors are only capable of detecting large or macroscale damages, such as large cracks or delamination. However, by the time an observable macroscale damage, such as a crack, is detected, most of the capacity of the structure has been consumed leaving little to no time for corrective action (or maneuver). The objective of this study is to investigate early stage structural damage also known as "unobservable degradation" in aerospace components using active thermogrphy. In the sequel, carbon fiber composite specimens are subjected to cyclic fatigue loading to gradually induce microscopic damage in the material. Active flash thermography images are then captured at regular intervals by pausing the cyclic loading. The thermal properties corresponding to applied fatigue cycles are later correlated to acoustic emission data, which are simultaneously recorded during the test.

I wish to acknowledge the mentorship of Dr Mulugeta Haile, the US Army Research Laboratory, and the Thurgood Marshall College Fund for this wonderful opportunity.

Proof of Principle for Approach that Eliminates Errors in BRL-CAD 3-D Graphics Models

Watson, Todd

BRL-CAD is an intricate graphics program that can be used to model anything from simple 3-dimensional (3-D) objects, such as a box, to extremely complicated ones like a tank. Unfortunately, more complicated objects are more susceptible to modeling errors, such as 2 objects occupying the same physical space, which is called overlap. Historically, the first procedure that was used to discover the modeling errors was a ray trace checking program (RTcheck). RTcheck heavily relied on user decisions and has been notorious for missing overlap errors. The deficiencies in RTcheck led to the creation of a quantitative analysis program (GQA). While GQA proved to be better than RTcheck, it does have one major flaw. If a ray barely grazes the edge of an object, it will show that the object is thicker than it actually is, which results in a modeling error. The error is minor and, therefore, does not actually need to be corrected to get the desired outcome; but it does make the process more computationally expensive. To solve this problem, I took a Quasi-Monte Carlo approach to ray trace a 2-dimensional (2-D) object. This was to enable me to "shoot" rays at different angles in a biased but balanced manner, without compromising the accuracy of the information produced. My objective was to test this new approach to find the critical mistakes in any given model and ultimately replace GQA.

I wish to acknowledge the mentorship of Clifford Yapp, Geoffrey Sauerborn, Elaine Hunt, and Sean Morrison.

Material State Awareness: Damage Quantification Through Coupled NDE Information and Computation Modeling

Whitmore, Ryan

A novel framework is presented to link measurable changes in the macroscopic properties of structures using microstructural scale damage monitoring. This framework intends to provide a new paradigm in diagnostics and prognostics of materials and structures through the integration of a multiphysics approach centered on nondestructive sensing, with experimental and computational mechanics concepts. To demonstrate this approach, Acoustic Emission (AE) and Digital Image Correlation (DIC) data were combined with computational modeling strategies to define ways to link structural behavior changes to material-specific effects. To achieve this goal, testing at both the microscale, using in situ mechanical testing inside a scanning electron microscope, and at the laboratory scale, were used to define a damage criterion that was then used in a finite element model to couple plasticity with damage initiation. Specifically, AE signals from damage mechanisms within the microstructure, such as precipitate fracture and void nucleation, served as inputs in a statistical outlier analysis to define a procedure that couples such acoustics parameters with damage related localizations monitored using DIC. A strain-based damage criterion was then defined based on the computed damage evolution curve, which was then normalized to represent a continuum based damage criterion that was used as input into a computational modal analysis approach that confirmed structural level damage effects.

I wish to acknowledge the mentorship of Dr Asha Hall.

Characterizing Thermal Properties of Materials and Efficiency of Thermoelectric Devices

Wilson, Adam A., ORAU Journeyman Fellow

Thermoelectric (TE) devices provide a means to address several challenges in developing equipment and power generation methods for the Solider of tomorrow. To inform development of the materials used in thermoelectric devices, energy conversion efficiency of the device (η), as well as that of the materials themselves (ZT) must be known. It is known that ZT may be increased through crystal lattice vibration suppression, which can be done by depositing repeating layers of thin film materials. When two dissimilar materials are in contact with each other, there is a finite limit to conductance across the interface. If this is not properly accounted for, artificially low measurements of κ will be observed, which leads to overestimating ZT, and may contribute to heat failure of devices.

Here we present strategies to measure these properties and report temperature-dependent efficiency of a lead-telluride/TAGS-based TE device and thermal conductivity of half-Heusler (metal alloy) materials. We propose three separate techniques to measure thin-film κ and G_i (time-domain thermoreflectance, 3-omega, and scanning thermal microscopy), each with unique strengths, providing a powerful suite of in-house characterization. By having three experiments capable of measuring thermal properties of thin films and interfaces in-house at ARL, we are able to provide valuable information to inform better material development, which will allow ARL to rapidly advance these materials (as well as others), since efficient feedback of thermal properties will be provided.

I wish to acknowledge the mentorship of Nicholas R Jankowski and Patrick J Taylor for providing insight to the tasks that I set out to achieve. I would also like to acknowledge Andrew N Smith (US Naval Academy), Michael Wraback, and Antonio Llopis-Jepsen (ARL Postdoc–ORAU Journeyman Fellow) for their valuable insight, lab space and equipment, and support in setting up a pump-probe experiment for time-domain thermoreflectance measurements.

The Development of Aural Cues for Helicopter Pilots in Degraded Visual Environments

Wojciechowski, Anna

Helicopter pilots have many responsibilities while on a mission, flying the helicopter being the most complicated and complex task. Often, pilots must fly through situations in which using visual cues is difficult, making things even more complicated. There are many situations that could cause a degraded visual environment for the pilots, including but not limited to nighttime, brown/white out, and bad weather. We are hoping to develop auditory cues that help pilots with tasks where they would normally use their visual system in order to keep the helicopter and its passengers safe.

My project at ARL has been to assist in the development of aural cues for aiding helicopter pilots in degraded visual environments. There were 4 main areas of focus to consider when choosing cues: navigation, obstacle and controlled-flight-into-terrain avoidance, multiship awareness, and threat warning. Each topic was researched and a study was design to help create cues that are intuitive but that do not annoy, startle, or increase workload for the pilot while containing all the information needed using only sounds. We created the protocol and studies to be conducted, including everything from setting up extra speakers, to writing code, to providing the pilot the studies.

I wish to acknowledge the mentorship of Mark Ericson.

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