ARL-TM-2015A ● DEC 2015

US Army Research Laboratory

Volume II: Compendium of Abstracts

by ARL Summer Student Research Symposium

NOTICES

Disclaimers

ARL-TM-2015A ● DEC 2015

US Army Research Laboratory

Volume II: Compendium of Abstracts

by ARL Summer Student Research Symposium

REPORT DOCUMENTATION PAGE						*Form Approved* *OMB No. 0704-0188*

1. REPORT DATE *(DD-MM-YYYY)* December 2015	**2. REPORT TYPE** Final	**3. DATES COVERED (From - To)**
4. TITLE AND SUBTITLE Volume II: Compendium of Abstracts		**5a. CONTRACT NUMBER** **5b. GRANT NUMBER** **5c. PROGRAM ELEMENT NUMBER**
6. AUTHOR(S) ARL Summer Student Research Symposium		**5d. PROJECT NUMBER** **5e. TASK NUMBER** **5f. WORK UNIT NUMBER**
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) US Army Research Laboratory 2800 Powder Mill Road Adelphi, MD 20783-1138		**8. PERFORMING ORGANIZATION REPORT NUMBER** ARL-TM-2015A
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		**10. SPONSOR/MONITOR'S ACRONYM(S)** **11. SPONSOR/MONITOR'S REPORT NUMBER(S)**

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

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 7 August 2015.

Students selected by their directorate for competition participated in the one-day Summer Student Symposium on 7 August 2015. 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.

15. SUBJECT TERMS

ARL Summer Student Research, SEAP

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON** Dr Vallen Emery
a. REPORT Unclassified	**b. ABSTRACT** Unclassified	**c. THIS PAGE** Unclassified	UU	62	**19b. TELEPHONE NUMBER (Include area code)** 301-394-3585

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

Contents

INTENTIONALLY LEFT BLANK.

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 2015, 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.

Thomas P. Russell
Director

INTENTIONALLY LEFT BLANK.

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.

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 expected 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 one or two papers from each competition category for the laboratory-wide competition at the Summer Student Symposium on 7 August 2015.

Students selected by their directorate for competition participated in the one-day Summer Student Symposium on 7 August 2015. At the symposium, the students presented their papers to an audience of ARL scientists and engineers, including 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.

Atomistic Modeling of High Strain Rate Deformation in Nano-Crystalline Mg

Agarwal, Garvit

HCP materials—such as magnesium and magnesium alloys—due to their high strength-to-weight ratio, have been deemed as promising candidates for next generation armor materials. A fundamental understanding of the deformation and failure response of the material during high strain rate deformation is required to develop the capability to withstand ballistic/blast impact. The mechanical response of these materials is primarily determined by the active deformation modes operating (slip, twinning, etc.) as well as the micromechanisms (voids, shear bands, etc.) related to failure. Of particular importance is the role of twinning in Mg due to the limited number of slip systems in HCP metals. The aim of this study is to identify the contribution and dependence of different atomic scale deformation mechanisms such as basal, prismatic, pyramidal slip and twinning on the microstructure of the system (i.e., loading orientation, grain size). Molecular dynamics (MD) simulations allow the characterization and investigation of the evolution of defect structures at the atomic scales during deformation and failure. Large-scale MD simulations are therefore carried out to investigate the deformation and failure micromechanisms in nanocrystalline Mg with grain sizes up to 30 nm under uniaxial stress and uniaxial strain conditions. The evolution of twinning during deformation, the dependence of peak strength on grain size, and the mechanisms of failure are discussed.

I wish to acknowledge the mentorship of Dr Ramakrishna Valisetty and Dr Avinash M Dongare for their support and guidance during the internship.

Bio-Hybrid Fuel Cells for Waste Mitigation

Benyamin, Marcus

In bio-hybrid fuel cells (BHFCs), the microbial breakdown of waste into fuel is directly combined with the electrochemical conversion of the fuel into electricity by a fuel cell. BHFCs have been demonstrated to have the flexibility of traditional microbial fuel cells, but with the (several orders of magnitude) higher power generation of fuel cells.

I investigated a setup to test a novel BHFC architecture that would be part of a system applicable to the Army's waste-to-water-and-watts problem, especially at forward operating bases. After designing, building, testing, and calibrating the setup, I also took all the data. I assessed the performance of the novel BHFC architecture under various conditions by doing chronoamperometry and linear sweep voltametry measurements with an electrochemical workstation. For the calibrations and for selected runs, I verified the component and product compositions using infrared spectroscopy. Using this data, I showed that the architecture fits a well-understood chemical reactor model (with zero adjustable parameters). This will allow us to extrapolate the expected performance of the system over the entire operating regime, and choose the best design parameters for the system, tailored to specific situations, without having to do experiments for every possible combination of parameters.

I wish to acknowledge the mentorship of Dr David Mackie and Dr Justin Jahnke.

Characterization of a Ho Doped Core/Tm Doped Clad Fiber Laser

Boccuzzi, Krysta

The use of an optical fiber with a Ho-doped core and Tm-doped cladding as a laser gain medium was explored. This fiber is advantageous because it lases at a longer wavelength than a fiber with a Tm core. In addition, the Tm cladding allows the fiber to be pumped over a larger mode area, while still achieving single mode output. The performance of several fibers of different lengths was analyzed by examining the laser efficiency, spectral output, and output beam quality of the fiber. Peaks near 1900 nm and 2090 nm were observed, indicating that both the holmium and thulium components were lasing.

Creating a Phantom Head Mold for Simulating Brain Electrical Activity

Burke, Benjamin

In order to develop various types of electroencephalography (EEG) headsets for future use by the Army, a gelatinous human head mold would be particularly advantageous. EEG is used to study brain electrical activity in order to measure brain function. A human head mold made of conductive gelatin with wiring inside would simulate the brain's electrical activity as measured at the scalp. We began the project by working through numerous iterations and designs of the mold via a computer design program. These “rough drafts” were used to test different types/concentrations of gelatin and different types of sealant for securing the mold before determining the components for the final mold. Future work will consist of comparing synthetic to organic gelatin to improve stability, as well as using conductive filaments (such as carbon nanotubes) to improve conductivity in the mold. From there, the optimal mold design will be chosen, and results will be collected and analyzed to determine the effectiveness of various EEG methods.

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

Implementing the Optimal Control-Based Obstacle Avoidance (OCOA) Algorithm in Compiled Code

Chang, Tyler

The OCOA algorithm was designed and implemented by Jiechao Liu and Tulga Ersal of the University of Michigan. The goal of the algorithm is to construct and solve optimal control problems (OCPs) in real time based on LIDAR data. The solutions are used to determine the optimal safe control adjustments for navigating a large unmanned ground vehicle to its target at high speeds while circumventing obstructions. The current algorithm is implemented in Matlab and calls the IPOPT library to solve the OCPs. To run the algorithm in real time, much of the code must be converted to C. This conversion will provide an inherent increase in speed, and will allow for future parallelization of the code. The goal of the Summer 2015 research has been to convert as much critical code as possible from Matlab to C. Specifically, the functions that directly access the IPOPT library are being fully converted to C and integrated back into the Matlab code using mex compilers. Thusfar, many subfunctions have been successfully converted and showed an increase in speed in the order of 5–10 times. The IPOPT handle functions have been started, but remain to be successfully reintegrated.

I wish to acknowledge the mentorship of Brian Rapp.

Application of Wirelessly Networking Raspberry Pi in a Head-Mounted Tactile Display

Chhan, David

In this work, I upgraded a wirelessly networked Raspberry Pi-powered head-mounted tactile display. The system is used to study the feasibility and effectiveness of head-mounted tactile signals for both directional and non-directional information displays. Intuitive and distinctive tactile signals could be used to coordinate Warfighter communications in a highly noisy and visual challenging environment while reducing cognitive workload. While a similar system using a full-size laptop already exists, the newly developed system provides great advantages in size and power consumption. The current system consists of 2 Raspberry Pi's wirelessly connected on an ad hoc network. One serves as the client, while the other serves as the server. The server unit has 4 tactile devices secured in a headband worn by the user. The client unit sends out commands to the server unit to produce tactile signals that are perceived by the user. The aim is to develop the current system to include a headphone, a microphone, and a bone conduction device to become a complete audio and tactile information display, while extending its capability to support squad communications.

I wish to acknowledge the mentorship of Phuong Tran, Joel Kalb, and Kim Myles. I would also like to thank the staff at the Perceptual Sciences Branch of the HRED for their warm welcome and support.

Characterization of Multirotor UAS Performance

Conyers, Stephen

This project will support research for collaborative unmanned air and ground vehicle missions. I am developing an unmanned ground vehicle (UGV) to support, service, and transport an unmanned air system (UAS). My research will enable collaboration with a UAS that has been built by the US Army Research Laboratory (ARL). This project will facilitate research for collaborative controls behavior development. This includes such research as developing behaviors to efficiently use the performance attributes of ground and air vehicles, and controls for robust collaborative landing techniques. The research will focus on how to characterize power use and efficiency of multi-rotor aircraft, which will include designing and fabricating experiment apparatus and performing characterization experiments for unique multi-rotor aircraft designs that may be used for collaborative missions with UGVs.

I wish to acknowledge the mentorship of Harris Edge and Jim Dotterweich.

Correlation of RCAS Load Predictions for Active Flap Rotor

Corle, Ethan

Active devices on helicopter rotor blades show promise for providing a reduction in vibrations, required power, and noise. As part of the Helicopter Quieting Program, Boeing's Smart Material Advance Rotor Technology (SMART) rotor was wind-tunnel tested to provide a data set for validation of current state-of-the-art prediction techniques. In follow-on studies, several computational tools were used to make predictions of blade loads for separate flap deployment schedules, but the correlation for each case was found to be fair or fair-to-poor. In this work, an investigation of the SMART rotor will be performed using alternative modeling techniques and codes that have not been implemented previously. Comprehensive analysis models for the SMART rotor have been developed through the Rotorcraft Comprehensive Analysis System. Updated aerodynamic modeling for blade loading, as well as rotor wake modeling, will be used. The results from these tests will be compared with each other, to experimental measurements, and to previous comprehensive analysis results. The goal of this work is to advance the modeling capability of active rotors so that accurate predictions can be made prior to expensive wind-tunnel testing or flight testing.

I wish to acknowledge the mentorship of Rajneesh Singh, Matthew Floros, and Hao Kang.

GNS3 Based Simulated Network Topology to Study Network Security

Crawford, Corey

The goal of this project is to create a simulated network topology to study the network vulnerabilities and their mitigation strategies. A simulated network topology is created using GNS3 and functional network nodes; firewalls are created using real Cisco IOS images. Routing, switching, and firewall functions are configured and the whole topology is divided into 2 segments—mimicking our own network and the adversary's network, which is trying to compromise our network. Using this virtual topology we have studied and analyzed malicious traffic patterns for developing mitigation strategies. Network design details and the results of our study will be presented.

I wish to acknowledge the mentorship of Dr Venkat Dasari.

Replacing Quantum Measurements with Noisy Unitary Gates

Cruikshank, Benjamin

There are several areas where our understanding of quantum physics is beginning to have a direct impact on information technology. These include unbreakable cryptography, secure networks, and exponentially faster algorithms for decrypting classical codes. Despite promise, many practical problems still exist in the efficient implementation of quantum technologies.

A standard requirement in quantum technology is the ability to make measurements of the state of a physical qubit. The reasons for measurement are to keep a record of a qubit basis state at various times, reliably process this basis information, perform conditional operations on the quantum system based on these results, and to promote decoherence of the qubit in a particular basis. It is a common assumption that a classical measurement apparatus, separate from the quantum system, is required to realize these effects. This leads to practical difficulty in implementing this efficiently into the technology, and is often a slow process.

Our research has shown that all requirements of single-bit measurements in quantum technologies can be achieved by a small set of noisy unitary gates. We explicitly developed 2 distinct architectures, based on multiplexing and concatenation, respectively. For each scheme we analyzed the practicality via rigorous noise threshold calculations.

I wish to acknowledge the mentorship of Dr Kurt Jacobs.

Incorporating Reliability in Rotorcraft Tradespace

Davis, Robert F

Preliminary rotorcraft design tends to focus on performance without consideration for factors that have a much greater influence on lifecycle costs, such as reliability, availability, and maintainability. The current research sought to explore the impact that reliability investments, primarily at the subsystem level, can have on rotorcraft operation and support (O&S) costs. Several government-developed tools were evaluated for usefulness in affordability analysis, but none fulfilled the need for rapid Tradespace exploration, due to the excessive inputs and opacity of mathematics behind the tools. A model was developed through a bottoms-up approach using previous research models as a base. The extended model establishes a framework to perform real-time tradeoffs between key factors related to rotorcraft affordability. A lightweight Tradespace tool began development using open-source statistical analysis and visualization tools.

I wish to acknowledge the mentorship of Eric Spero.

Enhanced Experience Replay for Deep Reinforcement Learning

Dawson, Bryan

Deep reinforcement learning has recently been shown to perform very well in learning control policies for Atari 2600 games. Using raw frames taken directly from an Atari emulator, these systems train a convolutional neural network to interpret the state of the game and select the optimal action. Temporal difference Q-learning is used to train the network, and a memory of state-action-reward transitions is kept and used in an experience reply algorithm to increase training efficiency. While recent work reports performance at or above the level of an expert human player on many of the games, when evaluating the behavior on a more qualitative level, there are major inconsistencies with the actions of an intelligent player. For example, the system tends to get stuck in infinite action loops in several games, often leading to very poor long-term average performance. To improve these behavioral characteristics, we introduce 3 new techniques. First, we bias the experience replay selection step towards state transitions that received a positive reward. Second, we compare newly observed states to a set of recently observed states, and take a random action rather than accept the action of the current policy if the states are similar to within a threshold. Finally, we only perform the reinforcement learning updates on the top-most linear layers as experiences are generated. This has 2 major effects: the training time is decreased by a factor of 10, and the state representations that are compared at each step are more consistent. We present the details of these improvements along with some preliminary results.

I wish to acknowledge the mentorship of Dr David Doria. This project would not have been possible without his guidance and insight.

Heterogeneous Computing – Dislocation Dynamics Acceleration

Demchenkov, Artem

Physical properties of crystalline material are governed by the presence of defects. Among various defects, dislocations play a vital role in inelastic deformation. For instance, the strength of crystalline metals is determined by the ability to hinder dislocation motion. The accurate modeling of dislocation motion is crucial to obtaining desired properties in engineering materials. Presently the accurate modeling of dislocation motion for large-scale models is too costly due to a few bottlenecks—parallelization of these bottlenecks will greatly reduce the modeling cost.

A heterogeneous program utilizes a GPU alongside of a CPU to reduce the compute time for an intensive calculation. The GPU threads perform computationally intensive kernels using local on-node data.

The research consists of using a heterogeneous programming language (CUDA C), to parallelize a bottleneck when computing the surface tractions for N number of dislocation segments. We will analyze the 2 major methods of computing surface tractions using CUDA; the first is an algorithm that assigns a single element per thread, and the second method uses an algorithm that assigns elements segments per thread. An analysis of both methods on the dependency on the number of threads and threads blocks yields the highest speedup of about 17.5.

I wish to acknowledge the mentorship of Joshua Crone.

Investigation of THz Surface Plasmon Propagation on Metal/Oxide Interfaces

Einsidler, Dylan

Terahertz (THz) frequency range is emerging as an interesting alternative for multiple applications, such as communications and chemical/biological detection. In order to implement devices in this frequency range, one needs to know the dielectric properties of the materials that will be used in these devices. Many applications would require usage of thin complex oxide films. It is very challenging to determine the dielectric constant of these films in the THz range. The goal of the project is to enable a new and better way to determine the dielectric constant (along with other properties) of extremely thin (200–500 nm) films deposited on metal substrate, using time-domain terahertz (TD-THz) spectrometry. We propose to accomplish this by means of signal detection and processing from surface plasmon polariton (SPP) waves generated on the metal/dielectric interface. However, the thickness of these films is significantly lower than the SPP field distribution above the metal surface. In order to achieve this goal, we first have to determine the profile (including the maximum height) of the SPP field distribution away from the metal surface. In this work, we research a novel approach for SPP field distribution determination, which includes correlation of first-order plasmon peak shift with the thickness of TiO_2 thin film deposited by Metal Organic Chemical Vapor Deposition (MOCVD). In addition, the proposed approach will be investigated for the capability to detect corrosion onset under protective coating.

Studying Open Quantum System Evolution of a Quantum Dot Qubit Using an Message Passing Interface (MPI) Scheme

Glenn, Terrell

Quantum computing (QC) is a paradigm for solving complex computational problems whose essential ingredient is a quantum bit, or qubit. Qubits are a generalization of the classical bit that can sustain a quantum superposition of 2 logical states. Quantum dots are small aggregates of semiconductor materials whose first 2 electronic energy levels provide the 2 states where one can encode information. Therefore, an important question to answer is, how long does this information survive the interaction with the environment?

This interaction, or lifetime, relates to the coherence time of an electronic state in the QD, which is dependent on its coupling to the environment that surrounds it. Using an interaction Hamiltonian matrix, interactions between a quantum dot and its environment can be modelled to describe the Schrodinger equation evolution for the QD's electron. Realistic environments are large and, due to the exponential size of the state space, produce a large interaction Hamiltonian matrix. Thus, parallel programming techniques can be utilized to break the problem into smaller pieces. The Message Passing Interface (MPI) is the standard parallel paradigm for high-performance computing, which was used to analyze the evolution of the qubit state, model more complex environments, and control numerical accuracy.

I wish to acknowledge the mentorship of Radhakrishnan Balu and Siddhartha Santra.

Phase Change Materials for Thermal Buffering in Transient Applications

González Nino, David

A number of Army electronic systems experience thermal transients during operation, which requires a package that can handle these peak thermal loads. Managing these peak loads can result in an overdesigned package requiring extra size, weight, and power (SWaP). The use of phase change materials (PCMs) in transient applications has been shown to be able to suppress hot spots or thermal peaks due to latent energy absorption during the phase change process, resulting in improved SWaP. Erythritol, a sugar alcohol, has been selected as a possible PCM for use in military applications due to its high latent heat and optimal melting temperature (118°C). In order to assess the applicability of erythritol as a PCM in thermal transient applications, a thermal profile comparison was made between a chip resistor package both with and without erythritol. These results were compared and contrasted with analytical equations; there was no significant difference in results between non-containing and containing erythritol chip resistor packages under tested conditions.

I wish to thank everyone who made possible this incredible experience; to my family who always have been very supportive, and to my mentors, Pedro O Quintero, Lauren Boteler, and Dimeji Ibitayo, who have guided me during this process. I also want to acknowledge Gail Koebke, Damian Urciuoli, Ronald Green, and Nick Jankowski, who have been very helpful on this project.

State-Transfer Protocol Using a Numerical Search

Gotshalk, James

Currently, I am researching the necessary C++ and Message Passing Interface (MPI) standard required to do a simulation on a supercomputer. The project my mentor is currently developing concerns the transfer of the state of a group of qubits to a Harmonic oscillator. It will involve doing a numerical search for a control protocol that will accomplish this task.

I wish to acknowledge the mentorship of Professor Kurt Jacobs.

Recursive Co-Kriging

Greene, Alexandra

Our goal in this work is to investigate various forms of kriging interpolation as they apply to the construction of surrogate models for hierarchical multiscale simulations. The focus of the research is to develop surrogate models that include results from multifidelity modeling and simulation. We started with kriging interpolation, which uses the results from a single level of fidelity in a simulation. Next, we used co-kriging and recursive co-kriging interpolation, which build more accurate surrogate models by using results from multiple fidelity levels. An advantage of co-kriging is that it has the potential to reduce the number of computationally expensive, high-fidelity simulations, while incorporating results from cheaper-to-compute, lower-fidelity simulations.

Recursive co-kriging is a co-kriging formulation, which builds independent krigings for each level in a multifidelity model. The recursive co-kriging model can be as accurate as that of co-kriging, but it has the benefit of using matrices of smaller size, which are cheaper to invert than the one large matrix required by co-kriging. The kriging models are then applied to dislocation dynamics models for determining critical stress.

I wish to acknowledge the mentorship of Claire Eisner.

Integration of Tactile Navigator and Virtual Simulation

Harman, David

It has become increasingly common to find System on Chip (SoC) devices to control transducers that stimulate various human senses—e.g., touch. The tactile sense is effective for sending intuitive, directional information, a discovery made possible using SoC devices in real-world experiments conducted on obstacle courses and outdoor pathways to measure Warfighter navigation performance in various military contexts. Recently, the experimental environment was extended to a realistic video game simulation. The simulation is set in a city scenario where players are required to navigate from point to point using a visual navigator. By arranging tactors on a player's head in a circular fashion, we can send signals to the head that map to cardinal directions in the environment and replace the visual navigator with a tactile navigator. My work was related to the programming code used to integrate the tactile navigator with the gaming engine. I added code to activate the tactors such that players could orient themselves toward a waypoint in the simulation and were able to distinguish nearness of a waypoint based on the frequency of the signals.

I wish to acknowledge the mentorship of Joel Kalb, Phuong Tran, Lisa Marvel, and Kimberly Myles.

Excited States of ^{108}Ag

Haughton, Jared

Isomers are especially long-lived energy states of certain nuclei, wherein the nucleus stores energy in such a way that it is difficult or unlikely to transition to a lower-energy state. As a result, isomers are an area of interest for use in long-term energy storage, if that energy can be released in a controlled manner on demand. The nuclide ^{108}Ag is a good candidate, having an isomer with a half-life of more than 400 years and a ground state half-life of just a few minutes. This project provided initial analyses of the data from an experiment conducted at the tandem accelerator facility, Japanese Atomic Energy Agency, Tokai, using a unique combination of gamma-ray and charged-particle detectors. The ^{107}Ag(^{18}O, ^{17}O)^{108}Ag reaction at 135 MeV was used to populate excited states of ^{108}Ag to determine the level scheme and search for decay paths to both the isomer and the ground state. This poster will discuss the results of the preliminary analysis of particle-gamma-gamma coincidences.

I wish to acknowledge the mentorship of Dr Jeff Carroll, as well as the frequent assistance and guidance of Drs Marc Litz, Jarrod Marsh, and Chris Chiara.

Exploring Communication and Process Spawning on the Cray XC40

Hoosier, Andrew

The Hierarchical Multiscale Framework (HMS) is a reusable framework to enable rapid development and deployment of new multiscale applications in peta- and exa-scale computing environments. On Cray machines, HMS must use sockets in Cluster Compatibility Mode (CCM) to communicate. However, CCM fails when running on 256 or more nodes, which is a problem for applications that need lots of processing power. Exclusive to Cray machines are low-level communication methods called Process Management Interface (PMI) and Generic Network Interface (GNI). PMI is a process manager similar to MPI and gets necessary information to setup GNI. GNI is a communication service that uses a Shared Message Queue (MSGQ) to communicate remotely and Short Messaging (SMSG) to communicate locally. Preliminary results show that PNI and GNI have a 3× speed-up over sockets with greater scalability. However, to use PMI and GNI in HMS there needs to be a method of spawning processes. Unfortunately, spawning processes has proved to be more difficult than expected. PMI's and MPI's processes for spawning methods are not implemented and using fork/exec leads to applications not recognizing other PMI processes. Hopefully, using sockets, along with fork/exec, to communicate necessary information to setup GNI will allow for process spawning with GNI communication.

I wish to acknowledge the mentorship of Kenneth Leiter for providing technical knowledge on the subject matter. He would also like to thank the US Army Research Laboratory and the Oak Ridge Institute for Science and Education for providing funding.

Self-Righting Robot in 3D

Hoppel, Mark

The goal of this project is to create a code capable of finding a set of joint motions for a robot to travel to so that it can right itself after having been tipped over. The current iteration of the code is designed for quasi-static conditions only. It is based off of similar code to re-right a robot in 2D, which was written by Chad Kessens.

The code works by mapping out the configurations the robot can pass through and identifying which ones represent an unstable state that will topple the robot. By finding a path between these unstable states, the robot can determine the joint movements it has to perform in order to bring itself to an upright position. While code exists that can accomplish this in 2 dimensions, this project serves to upgrade the code and expand its capabilities. Significant upgrades include the ability to apply forward kinematics in 3D, the ability to handle 3D point meshes, the redefinition of a face as a single planar face of the robot, the ability to handle joint motions out-of-plane, and the ability to orient the robot on a 3D ground plane.

I wish to acknowledge the mentorship of Raymond Vonwahlde and Chad Kessens.

Van der Waals Solids: Chemical Vapor Deposition Growth and Characterization

Kahn, Ethan

In recent years, there has been great interest in layer number controlled growth of atomically thin van der Waals (vdW) solids on planar substrates for optoelectronic applications. As the field of 2D materials matures, attention is now turning toward stacking dissimilar vdW materials in search of unique functionalities and emergent properties. Furthermore, vdW solids can be sculpted into 3D frameworks. Here we synthesize and characterize ultralight (~2mg/cm^3) hexagonal boron nitride foams. Due to their deformability and their inertness at temperatures up to 1200 °C, the foams synthesized will be tested as a possible means to safely store energetic materials. Nevertheless, this material is not as robust as might be hoped for. Possible means of enhancing its mechanical properties are introduced. The work performed during Summer 2015 will be extended in the future as part of a long-term collaboration between ARL and Penn State University.

The Effects of Sputter-deposition Parameters on the Adhesion of Copper to Photoresist for Micro-Fabricated Power Components

Kessler, Emily

Integrated power inductors for power management require multiple layers of electroplated metals patterned through photo-definable molds. A significant micro-fabrication challenge remains with the interface between the sputter-deposited metal seed layers and the underlying molds; this interface is subject to tearing and cracking due to thermally induced stresses. A new processing capability promoting the adhesion and strain relief of sputtered copper to an organic substrate is investigated. By pre-straining and reticulating the photoresist and then sputtering copper, the copper is allowed to flex in-plane without cracking or tearing when further thermal steps are taken. Because copper does not readily adhere to organic substrates, an oxygen-enriched plasma is first used to activate the surface of the mold. Using 2 four-factor Box-Behnken response surface models, adhesion quality and reticulation roughness are compared against the parameters of the oxygen-enriched plasma. The adhesion of the sputtered copper to the mold is evaluated using a tape test, while the surface roughness is measured with a laser confocal scanning microscope. From these tests, two model equations are extracted and compared.

Port Scan Detection

Kindrick, Tamarick

The Transport Layer, or Layer 4, of the OSI model contains the entity called Port. It is not a hardware device but a logical entity combining an Internet Protocol (IP) address and a protocol. A Port Number is a 16-bit unsigned number assigned to a port and it spans the decimal numbers between 0 and 65535.

Port Scanning is an activity used by hackers and cyber-criminals to determine if a port is open or closed. An open port can be used by people with malicious intent to get private information from computer networks. A port scan detector would be very useful and essential for alerting a user if a scanner wants to hack inside the target network through port scanning. This issue is difficult to detect because it is hard to define a malicious scan, some Internet traffic could appear as a scan from search engines.

To approach this issue I am analyzing simulated Internet traffic from a file containing captured Internet traffic packets. This file is read by a pattern-recognition program running on the same machine. For that purpose, the traffic file is converted to a text file, which is read by the program. The user enters a specific port number or any general alphanumeric sequence. If the sequence is found it will display the location in the packet file where it was found. If the sequence is not found the user will be prompted to try the search again. If the sequence for a source port number is displayed multiple times, then this could be a sign of a port scan.

I wish to acknowledge the mentorship of Dr Vinod Mishra and Dr Venkat Dasari.

Analysis of Slip System Dependence on Threading Dislocation Population in Epitaxial Film and Bulk Single Crystal GaN

Krimsky, Erez

In this work, a thorough analysis of slip systems in GaN with 3 different dislocation densities has been performed via micropillar compression and spherical nanoindentation. The yield strength of the material was found to have a large dependence on the dislocation density. Two distinct failure behaviors have been distinguished—one relating to failure at the strength of perfect material, and one relating to the activation of ingrown defects produced during crystal growth. A variety of mechanisms for the 2 behaviors have been suggested, mainly homogenous nucleation of dislocations and pinning via dislocation interaction, respectively. Simulations have been performed to verify these 2 distinct failure behaviors. An analysis of the resolved shear stress for each potential slip system has been performed using Hertzian contact assumptions for an elastic indenter into an infinite half-space to shed light on the relevant slip systems. To our knowledge, this is the first microcompression study on GaN with multiple dislocation densities and the largest range of dislocation densities used for any GaN nanoindentation study to date.

I wish to acknowledge the mentorship of Brian Schuster, Kenneth Jones, and Jonathan Ligda.

Constitutive Model for Open-Celled Foam

Kury, Matthew

Foam pads in combat helmets serve to provide separation between the wearer's head and the helmet shell. During impact events these pads play an important role in momentum transfer from the helmet to the head. In order to improve the protection these foam pads provide, an investigation was made into the combat helmets used by Team Wendy Zorbium.

The investigation consists of 2 parts: formulation of a mesoscale constitutive equation to accurately recreate the foam's behavior for helmet scale, and the exploration of the physical responses of the foam microstructure under impact-loading conditions. The focus of the research this summer has been on the development of the mesoscale constitutive model. A thorough survey of current foam models and a parameter fitting for a compressible Ogden hyperelastic model were conducted. Simulations have shown that the model gives a good fit for low strain rates; however, it needs to be extended to appropriately recreate the behavior at higher strain rates.

I wish to acknowledge the mentorship of Dr Sikhanda Satapathy for his mentorship this summer; and thanks also to Dr Jennifer Sietins and Dr Chris Meredith for their experimental expertise.

JP-8 Catalytic Burner for Thermoelectric Power Generation

Lan, Helen

The Army's JP-8-fueled kitchen burner, the Modern Burner Unit (MBU), generates large amounts of waste heat and produces toxic gases. Catalytic combustion is the key to solving these problems. The proposed solution is a burner that is heated by catalytic combustion of JP-8 and simultaneously generates electric power.

To accomplish this, a thermoelectric module is placed on top of a catalytic burner. The equivalence ratio and contact time of the JP-8 combustion reaction are varied to determine the conditions for a steady temperature profile. The hot side of the thermoelectric generator is kept hot through catalytic combustion in the burner, and the cold side is kept cold by the water. The temperature difference created within the thermoelectric generator results in a voltage difference and power output. This technology could potentially enable portable power generation in sustainment systems with Army logistic fuels. Future studies will aim to maximize the electric power output by maximizing the temperature difference within the thermoelectric generator.

I wish to acknowledge the mentorship of Dr Ivan Lee and Dr Zachary Dunbar.

Modal Analysis for Predicting Damage in UHMWPE Composites and Determination of Resulting Backface Deformation

Le, Jacqueline

This study explores non-destructive evaluation techniques for detecting damage in the Enhanced Combat Helmet (ECH), which is comprised primarily of Ultra High Molecular Weight Polyethylene (UHMWPE). The goal is to use modal analysis before and after damaging a curved UHMWPE panel, and measure the changes in natural frequencies and mode shapes of the panel. Damage will be introduced using an instrumented low velocity drop tower test in which repeated impacts will simulate normal handling of a helmet. Any changes in the modal analysis will then be correlated to actual damage measured using a medical CT scanner. The representative ECH specimens will be ballistically interrogated at a constant velocity and the backface deformation of the specimen will be measuring using digital image correlation. The hope is to then determine if there is a negative effect on the allowable backface deformation of the helmet, which may have a significant impact on the survivability of the Warfighter. Ultimately, it is hoped that modal analysis can be employed as a non-destructive technique to determine the threshold level of damage in this class of material, which may negatively affect performance in the field.

I wish to acknowledge the mentorship of Shane Bartus. I would also like to acknowledge the leadership of Patrick Swoboda and Matthew Burkins. Many thanks go to Lionel Vargas, Natasha Epps-Bradley, and Michael Coatney for their help.

Computational Solutions Using "HOMER" Software

Lee, Joshua E

Over the last several decades, technology and a need to cure various diseases have driven genomic research. Both revolutionary and evolutionary developments have been critical for achieving the remarkable increases in big data and reductions in costs of DNA sequencing.

As initial findings indicate potential benefits, they must be followed by clinical studies to demonstrate effectiveness. Based on the strategic plan released by the National Human Genome Research Institute entitled, "Charts Course for the Next Phase of Genomics Research," 8 areas are continuously being investigated to achieve the end goals: new technologies, large-scale collaborative efforts, multidisciplinary and international teams, comprehensiveness, high-throughput data production/analysis, computational intensity, high standards for data quality, rapid data release and attention to societal implications.

The purpose of this experiment was to identify an adequate software that could sequence genomic data as well as find motifs in large-scale genomes through a process called Hypergeometric Optimization of Motif EnRichment (HOMER). We examined HG00096 DNA, a blood sample with Epstein–Barr virus (SRR062634.filt.fastq data set), and aligned to Human Genome 18 (hg18). We believe the results from the experiment will assist ongoing research towards finding a cure for the Epstein–Barr virus.

I wish to acknowledge the mentorship of Dr Radhakrishhnan Balu, Chief Colleen Adams, Mr Jerry Arp, and the High Performance Computing Network Branch.

Visualizing the Radio Spectrum Across Irregular Terrain

Levine, Brian

Understanding the temporal and spatial usage of the radio spectrum resource is required for the simulation and emulation of wireless radio networks. Computing the energy received by wireless radios requires careful consideration of the environment and its effects on radio frequency (RF) propagation. Specifically, radio signals degrade over distance, terrain, vegetation, and many other obstacles, leading to signal-strength attenuation and changes in received power. The Longley-Rice algorithm has been shown to effectively predict the path loss between transmitters and receivers over irregular terrain. To help visualize these effects, a tool is being developed using National Aeronautics and Space Administration (NASA) World Wind to determine the net received power for different RF environments in irregular terrain. This tool utilizes the Longley-Rice algorithm as well as the computational power of graphics processing units (GPUs) to determine received power values for multiple RF links. Written in Java, Python, and C, the program includes visualization capabilities in World Wind, a framework for sending coordinate and path loss values through UDP and TCP ports, and the ability to select coordinates and frequencies for every transmitter in the 802.11 standard. Here I will present my work in developing a method to compute and visualize the radio spectrum for mission and spectrum planning.

I wish to acknowledge the mentorship of Dr Brian Henz, US Army Research Laboratory (ARL) Simulation Sciences Branch, for all of his insightful knowledge and encouragement. I would also like to thank Mr Scott Brown and Dr David Richie at ARL for their help in developing the visualization tool and computation engine, respectively. I also thank Ms Virginia To for coordinating this summer's research, and the rest of ARL's Computational Sciences Division for their moral support.

The Effect of Dislocation Evolution for FCC Materials Under Shock Loading

Mackenchery, Karoon

The design of next generation materials for armored applications is dependent upon understanding the mechanisms of failure at the atomic scale. The failure of these materials at the macroscale is largely determined by the evolution and interaction of defect structures at the atomic scale during a deformation process. A fundamental understanding of the role of defect evolution at the atomic resolution and the related contribution to plasticity at the macro-scales is needed to obtain a reliable performance of metallic materials in an extreme environment.

Large-scale molecular dynamics (MD) simulations are used to characterize the dynamic evolution of defect structures (dislocations, twins, stacking faults, etc.) for various microstructures under extreme loading conditions of high strain rate deformation. The MD simulations are carried out for single crystal and nanocrystalline metals (Cu, Al) under shock loading conditions. The defect structures generated in these MD simulations are characterized using various computational tools. The evolution of various types of dislocations, twins, faults, etc., and the related deformation and failure response is investigated. The relationships between the microstructure, defect density, and dislocation type, will be discussed.

I wish to acknowledge the mentorship of Dr Rama Valisetty and Dr Avinash M Dongare for their support and guidance during this internship. The author would also like to thank ARL for this wonderful opportunity and use of their exceptional computational resources to conduct this research.

Determining the Performance of Application Run on High Performance Computers

Malley, Mikayla

Determining the performance of applications that will be run on High Performance Computers (HPC) is an important yet very complex task in the HPC field. One way to determine performance is to utilize benchmark kernels that are representative of typical applications found in the science and engineering field. This project investigates the benchmark kernel Backtrack and Branch and Bound (BBB), which searches for the solution to a problem among a variety of potential solutions. Within the algorithm, if the first choice proves incorrect, then computation backtracks or restarts at the point of entry and selects another option. For this project, we chose the particular BBB algorithm, N-Queen, which is used in the game of chess and defined by the set of N-Queen configurations. WORK included implementing the algorithm in opencl and running it on an accelerator. The work presented here will incorporate the first steps to adding an autotuning methodology to the kernel to ensure optimal kernels are being run on any HPC. After completing the project, the results concluded that the smaller the number compiled, the quicker and more consistent the runtime; but the larger the number compiled, the slower the runtime and the numbers fluctuated.

I wish to acknowledge the mentorship of Jamie K Infantolino.

Correlations Between Tetris Fall Speeds and Eye Movement

Mallick, Rohit

Understanding how eye movement patterns correlate to cognitive states, such as workload and fatigue, may provide better insight into Soldier performance. The current experiment evaluated eye movement patterns during different levels of cognitive workload. To manipulate workload, we implemented a Tetris task by varying the fall speed of the block. The Tetris task is a well-known game in which different types of blocks fall. The objective of the game is to align them so that they do not reach the top. Blocks fell at slow, medium, and fast speeds, which we defined as low, medium, and high workload, with 2 trials for each speed. While doing the Tetris task, subjects also performed a separate auditory discrimination task. We measured features of eye movements (blinks, saccades, fixations), and predicted that they would relate to performance and workload level in the Tetris task. Our results showed that features of eye movement metrics correlated with the workload manipulation and suggest certain features of eye-movements can augment current Soldier performance-based metrics.

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

Weapon Displacement During Controlled-Pair Firing of Small Arms Weapon Systems

McKee, Daniel

When firing a weapon, a shooter experiences recoil—the backward momentum of a weapon after trigger pull. Many factors, such as round size, weapon size and weight, and muzzle devices, can influence recoil magnitude. The goal of this project was to determine how different muzzle devices, applied to different caliber rifles, affect the amount of recoil displacement. To do this, motion capture was used to track the position of the weapon, as 8 subjects with marksmanship training performed controlled-pair shots at a specific target. This shot scenario allowed us to examine the amount of displacement of the rifle from the moment just after firing the first round to the moment directly before the second shot was taken, enabling us to examine the displacement due to recoil as the subject attempted to remain on-target. Weapon conditions included 3 different calibers (5.56mm M4 carbine, 6.8mm M4 carbine, 7.62 M110 rifle variant), coupled with 3 different muzzle devices (birdcage, muzzle break, suppressor). For this project, I named, exported, and analyzed motion capture data points on the shooter and rifle in order to examine the amount of weapon displacement after firing.

I wish to acknowledge the mentorship of Courtney Webster.

Passive Vibration Control of a Full-Scale Tailboom with Fluidic Flexible Matrix Composite Tubes

Miura, Kentaro

With low inherent structural damping, rotorcraft tailbooms vibrate due to periodic excitation from the main rotor and broadband excitation from aerodynamic forces. Tailboom vibration causes structural fatigue, decreases the lifespan of sensitive components, and reduces pilot and crew comfort. Despite prior research in active, semi-active, and passive vibration treatments, heavy and bulky proof mass actuators remain the typical standard used in many production helicopters. Fluidic Flexible Matrix Composite (F^2MC) tubes are a promising new class of high-authority, lightweight fluidic devices that can passively provide damping and vibration absorption. A prototype F^2MC-based absorber is designed and fabricated based on a model of an OH-58C helicopter tailboom with F^2MC tubes. The prototype absorber is installed and tested on an OH-58C helicopter to experimentally demonstrate performance and validate the model. Preliminary simulation results indicate that a F^2MC absorber can reduce response at the first tailboom vertical bending mode by over 80%.

I wish to acknowledge the mentorship of Dr Hao Kang, Dr Matthew Floros, and Brent Mills from the US Army Research Laboratory (ARL); Peter Romano and Mike Seifert from Bell Helicopter; and Dr Edward C Smith and Dr Christopher D Rahn from the Pennsylvania State University, and support from Penn State research assistants Matthew Krott and Steven LaBarge.

Production of Textured Alumina Bodies by Magnetic Alignment Using Novel Gel Casting System

Moorehead, Carli

Alumina has many favorable properties, but it is very challenging to make transparent because of its anisotropic crystal structure. To combat the anisotropy, it is theorized that magnetic alignment of the particles such that the change in index of refraction is minimized from grain to grain, thus reducing light scattering, will allow transparency. To do that, a processing method that provides a liquid medium in which the particles can rotate during alignment then freezes them in place after alignment is necessary. This work describes a gel-casting method using a novel water-soluble gelling system of isobutylene and maleic anhydride co-polymer that provides such a mobile liquid medium necessary for magnetic alignment. It then forms a network *in situ*, at very low concentrations (0.3–0.5 wt%), that traps the particles in place and prevents misalignment prior to sintering. The product is a dense, near-net shaped green body with high solids loading, low organic content, low shrinkage, and moderate strength. This work focuses on the adaptation of this gelling system to variously sized particles, characterization of the gelling system and green bodies, and investigation of the gel formation mechanism.

I wish to acknowledge the mentorship of Dr Victoria Blair and Dr Jane Adams for their mentorship, along with all the members of CTMB and MMTB who have instructed and guided me throughout the summer.

Possible Deformation Mechanisms of ASB Formation in Ti7Al

Nguyen, Lynn

High-strength metals tend to form adiabatic shear bands, or localized zones of intense shear strain, under dynamic loading conditions. A single-phase, binary Ti-7Al (wt%) alloy formed by extrusion and rolling processes was investigated due to its high hardness and strength. The as-rolled and annealed samples were put through the Split-Hopkinson Bar test (at $10^3 s^{-1}$), with respect to the rolling, normal, and transverse directions. Loading in the normal direction formed shear bands that led to failure. The fractured surfaces of the failed samples were imaged with an scanning electron microscope (SEM) to see deformation morphology. Electron backscatter diffraction (EBSD) imaging was used to determine possible deformation mechanisms, such as slip, twinning, and dynamic recrystallization.

I wish to acknowledge the mentorship of Dr Brian Schuster, for guiding me through this project; Dr Emily Huskins for performing the compression tests; Alexandria Will-Cole for doing the mechanical analysis; and Dr Somnath Ghosh at Johns Hopkins University for leading the project on modelling the deformation behavior of titanium alloys.

ab initio Calculation of Doped Alumina for the Purpose of Field Induced Texturing

Nykwest, Erik

Crystallographic texture can have a profound effect on the macroscopic properties of a material. One method of texturing is through the application of an external magnetic field before or during the processing of materials to tune the microstructure and produce superior products. While this method works well with highly magnetic systems, doping is required to couple non-magnetic systems with the external field. This work focuses on the use of density functional theory (DFT) to predict structural, electronic, and magnetic properties of doped alumina powder to search for optimum dopants for the purpose of texturing.

I wish to acknowledge the mentorship of Tanya Chantawansri (Team Lead), Krista Limmer, Mahesh Neupane, Ray Brennan (Project Lead), Victoria Blair, Professor Ramprasad (Advisor, UCONN), and Dr Jan Andzelm (Modeling Mentor).

Army Asset Visualization

Perry, Vincent

Data collection, processing, and analysis are essential to the understanding and improvement of Army endeavors. The purpose of this project was to create a three deminisional (3D) simulation of Army assets using the Visualization Toolkit (VTK). VTK is an open source software system primarily used for 3D graphics and visualization. This project utilizes the vtkGeoView class to import 3D models using latitude and longitude coordinates, and connecting those models with colored tubes to depict various radio communication waveforms. The models animate using location, connection, and movement data from an emulation scenario. The simulation contains both mobile aerial assets including static land and water assets with radio connections between them. When aerial units undergo turning maneuvers, the radio connections to non-moving water and land assets disconnect only to connect again when the turn is complete. Because this simulation was created in VTK, it can be viewed in 3D using CrystalEyes LCD shutter glasses. Given the location, connection, and movement data provided, the Visualization Toolkit is a very resourceful open source software that can be utilized to create 3D simulations to analyze the data's impact and significance for the Army.

I wish to acknowledge the mentorship of Scott Brown.

Reducing Communication and Computation Cost in Coupled N-body Simulations

Pham, Harry

My research project was to develop a better framework for passing data that improved communications using a distributed shared memory (DSM) system. The purpose was to determine if the DSM can be used to couple the Parallel Dislocation Simulator (ParaDiS) and a finite element method (FEM) program. Coupling ParaDiS and a FEM program would allow researchers to simulate and calculate the effect of external forces on dislocations within a crystalline material and how this affects the material's strength and structural integrity. More generally, my work dealt with issues resulting from multiple program multiple data programming (MPMD), focusing on scalability concerns for such programs.

When calculating dislocation stresses, all dislocation segments interact with each other, similar to interactions between point charges. As a result, the computation cost is expensive at $O(N^2)$ for N number of dislocation segments. Computational and communication times can be reduced by using the multipole expansion or the fast multipole method, with the latter reducing computational cost to O(N). However, these methods add a layer of complexity to the DSM in terms of data management and storage. My research aimed to test if the DSM had the capability to handle this and what performance gains could be realized.

I wish to acknowledge the mentorship of Joshua Crone for his guidance throughout my project, and Andrew Burns for his help with the DSM system.

Dielectric Barrier Discharge Synthesis of Energetic Materials from Carbon Monoxide

Pollard Jr., William

Increasing the energy density of energetic materials allows military units greater damage capabilities without the burden of additional encumbrance. Advanced energetics are often formed by forcing a material into an exotic phase, which often requires the use of very high pressures and sample sizes on the order of μg—as is the case in diamond anvil cell testing. Plasma enhanced chemical vapor deposition (PECVD) provides partial access to these exotic phases at ambient pressures. A general introduction to plasmas is discussed, as is plasma's unique benefits to chemistry. In this research, a carbon monoxide (CO) dielectric barrier discharge (DBD) plasma is used to deposit thin films of p-CO/p-C_3O_2 on a borosilicate substrate at atmospheric pressure. Laser shock testing of the deposited film indicate potential for use as an advanced energetic, but chemical analysis and visual inspection show molecularly inconsistent films. An annular rasterizing DBD reactor has been designed that may maintain the ~290 K temperatures required by chemical kinetics for uniform deposition of the desired p-CO/p-C_3O_2 species.

I wish to acknowledge the mentorship of Jennifer Ciezak-Jenkins, Tim Jenkins, Chi-Chin Wu, and Andy Bujanda.

Vibration Suppression through Piezoelectric Shunt Circuits

Powell, Preston

Vibration control of flexible structures has been extensively researched over the past three decades. Numerous active and passive damping mechanisms have been developed and implemented for suppression of vibrations in aerospace structures. Piezoelectric materials have been the foundation of a large amount of such devices. These materials have a unique property, in that they produce an electric charge under an applied stress. Conversely, an electric field applied to a piezoelectric material will produce a mechanical strain. Although active control provides higher damping, it is not practical for vehicles such as helicopters due to the added complexity of introducing an external power source. A completely passive control mechanism would be ideal for rotorcraft. One method for passive vibration damping using piezoelectric materials is the use of an electrical shunt circuit to dissipate energy. In this study, variations in such a shunt are modeled and numerically evaluated to assess the passive damping capabilities of piezoelectric materials mounted on a cantilever beam.

I wish to acknowledge the mentorship of Dr Hao Kang for providing the opportunity to work on this project. Secondly, I would like to thank and acknowledge Dr Jinwei Shen, my academic advisor, for his support and advice during this study. Lastly, I express my gratitude towards Dr Jin Hyeong Yoo for his helpful comments and contributions during weekly meetings.

Implementation of Multipath Transmission Control Protocol (MPTCP) Over the Standard Transmission Control Protocol (TCP)

Ramgolam, Asha

In a Software Defined Network (SDN), the implementation of Multipath Transmission Control Protocol (MPTCP), in comparison to the standard Transmission Control Protocol (TCP), significantly increases availability of resources. MPTCP functions over TCP at the fourth layer of the OSI model (transport layer), and can be located between a TCP header and packet data. Current TCP although efficient, is limited by its inability to provide support for high availability, seamless roaming, link aggregation, and mesh networking. MPTCP differs from TCP because it offers high availability, seamless roaming, link aggregation, and mesh networking features and more.

To test the aforementioned features of MPTCP versus TCP, five Virtual Machines (VMs) will be configured with and without MPTCP, guest additions, Mininet, Netcat and more. Furthermore, they will be set up as servers or clients to run Iperf and generate traffic between the VMs. The traffic will be captured by a network monitoring tool such as Wireshark with OpenFlow. The packet captures will then be analyzed using both Wireshark and Kali Linux. The findings will be recorded and compared in various manners. Lastly, a topology will be created in Visio to provide a visual aid of the test network.

Security is essential for a network to function reliably; by using MPTCP vulnerabilities may increase due to cross path traffic, moving targets (changes in IPs), connection resilience and more. Whether the convenience of higher availability should take precedence over possible vulnerabilities introduced by MPTCP not been determined. This is a subject that is currently being examined mainly in European countries. Kali Linux will allow us to analyze possible weaknesses presented through the implementation of MPTCP.

I wish to acknowledge the mentorship of Dr Venkateswara Dasari.

Modeling and Simulation of a GaN Betavoltaic Energy Converter

Ray II, William

Gallium nitride (GaN) semiconductor devices have the potential to improve the efficiency of direct energy conversion (DEC) and indirect energy conversion (IDEC) isotope batteries, making available long-lived power sources. However, knowledge is needed of the underlying semiconductor physics and subsequent electron transport when GaN is exposed to higher energy electrons typical of beta emission by ^{3}H. A model of a GaN betavoltaic (βV) device was simulated using Silvaco ATLAS device simulation software. Numerical calculations are compared to experimental results obtained from prior experimental parameter studies of a GaN P-u-N diode. The material parameters of the GaN device have been determined by matching the experiment P-u-N "dark" forward characteristics, while the βV response of the GaN simulation was matched to the results of the P-u-N device when irradiated by an electron beam [2-16 keV]. The device efficiency and maximum power point with respect to different energy electron beams of the experiment and simulation are then compared to verify the model. The simulation model matches with the results of the real βV device. The GaN simulation model developed can be used to verify the fundamental material characteristics of the as-grown GaN, understand the design challenges, and optimize the efficiency of the βV process in different GaN device structures offering higher energy conversion efficiency than 2D geometries.

I wish to acknowledge the mentorship of Dr Marc Litz, for his advice and guidance throughout the summer.

Electroplated Solder for Multilayer Power MEMS

Rosenfeld, Adam

Multilayer metal micro-electro-mechanical systems (MEMS) enable compact and efficient power components for integrated power management. Currently, metal MEMS fabrication uses the stacking of sacrificial photoresist and metal seed layers. This process is subject to thermal limitations in the photoresist, which restricts the number of layers and the thickness of each layer that can be achieved. Additional layers enable higher inductance densities, and thicker layers reduce conduction losses—both increasing the quality of the component. A proposed solution to this problem is using a solder-bonded multilayer process. Each layer is built on different substrates and then bonded together using solder reflow. Initially, a blanket layer of either copper or gold is deposited as a seed layer for the electroplating. Next, an electroplating mold is formed with photoresist. Then copper or gold is electroplated through the mold. A thin nickel cap is electrodeposited to serve as a diffusion barrier. Next, tin-silver solder is electroplated on top of the nickel. All photoresist is then removed. The substrates are aligned and bonded, and one of the substrates is removed. This process is repeated until the desired number of layers is achieved. In this work, characterization of the electroplated solder and the bonding of various MEMS structures will be covered.

Passive Piezoelectric Shunt Damping Design

Sun, Tiffany

Passive vibration damping can be augmented by attaching shunted piezoelectric transducers to a single degree of freedom system. Using the actuator and sensor equations of the piezoelectric system, along with Ohm's law, one can derive a position transfer function of the shunted system that compares amplitude to frequency. After the transfer function is obtained, it can be used to compare four different systems: a single piezoelectric transducer, 2 independent piezoelectric transducers, 2 piezoelectric transducers connected in series, and 2 piezoelectric transducers connected in parallel, alongside 3 different impedances: resister-inductor (RL) series, RL parallel, and resistor-inductor-capacitor (RLC) series. From the acquired graphs, one can see that the 2 independent piezoelectric transducers attached to the single degree of freedom system with an RL series shunt reduces vibration the most effectively. However, it is noted that adding an additional piezoelectric element does not double the damping effect; adding additional piezoelectric elements to the system will not linearly increase the amount of damping done to the system.

I wish to acknowledge the mentorship of Dr Hao Kang, who was able to help provide this opportunity and give plenty of feedback throughout the process. Furthermore, I would also like to thank Dr Jin Hyeong Yoo and Jinwei Shen for their help and guidance each week.

Characterization of Long-Term Gross Spectral Change in Varied Auditory Background Scenes

Suwangbutra, Jitwipar

Ambient dynamics of common acoustic backgrounds are complex, and can vary widely based on time and location. They are vastly under-documented and, thus, not typically available as parameterized stimulus sets. For this present research, I developed and documented systematic methods for capturing and analyzing long-term ambient environmental sound recordings. Long-term sound recordings were collected from three diverse free-field sound environments. Sound detectability is dependent on the signal-to-noise (SNR) ratio between the actual level of the sound source, and the ambient background at a specific location and distance to the sound source, itself. Further examination of detection predictions may provide insight on what types of spectral-temporal changes might be important to consider when designing experiments that measure real-world behavior.

I wish to acknowledge the mentorship of Dr Jeremy R Gaston.

Embedded OpenFlow Controller for Managing Small Software Defined Network (SDN) Topology

Tarantin, Ian

Due to its programmability and flexibility, Software Defined Networking (SDN) is a rapidly growing technology that will be used to build next generation networks. In our study we have embedded a SDN controller onto the Raspberry Pi computer board, and evaluated its ability to quickly setup and control a small SDN network topology, similar to the ones encountered in tactical networks. Security, performance, flow dynamics and ease of use of the embedded controller was also studied to ensure the robustness of the proposed design. Details of the design and the results of security and performance tests will be discussed.

I wish to acknowledge the mentorship of Dr Venkat Dasari.

Installing a Wireless Network

Uddavolu, Jyotsna

The report presents the five tasks completed during the summer internship at US Army Research Laboratory (ARL) which are listed below:

- Planning for installing a wireless network with voice over IPs in 2 similar 2 story buildings with 750ft length each floor, which has 250 people per floor. Each person uses a laptop and a cellphone.
- Diagram for the wireless network with voice over IPs using Cisco icons.
- Resources required for the entire project.
- The cost management of the project
- The time line for the completion of the project in Microsoft Project.

I wish to acknowledge the mentorship of Mrs Collen Adams for providing ideas to work upon. I am also highly indebted to Selena Lowry and Asha from the network team who seemed to have solutions to all my problems.

Scalable, Decomposable Approach for Lattice Dynamics in Structures Containing Defects

Weisburgh, Rose

The US Army has great interest in next-generation electronics with greater space and energy efficiencies beyond the capabilities of silicon. As electronic components such as transistors reduce in size, defect detection and location is becoming increasingly desirable because each individual defect has a larger effect on component properties. A number of methods can determine whether damage exists within large-scale structures by inducing vibrations and measuring the response (Salawu OS. "Detection of structural damage through changes in frequency: a review." *Engineering structures* 19.9 [1997]: 718–723).

Previous works in lattice dynamics have developed equations to obtain theoretical frequency responses of defective materials (EW Montroll, RB Potts. "Effect of defects on lattice vibrations." *Physical Review* 100.2 (1955): 525;M Wagner, T Mougios. "Thermodynamics of mesoscopic soft modes in strongly disturbed lattices." *Physica A: Statistical Mechanics and its Applications* 166.2 (1990): 229–262;IM Lifshitz, AM Kosevich. "The dynamics of a crystal lattice with defects." *Reports on Progress in Physics* 29.1 (1966): 217); however, the formulas require the computation of complex integrals and solutions must be recalculated for any change in geometry, defect orientation, or defect concentration.

In this work, we have performed a series of numerical experiments suggesting a new, modular approach may exist for decomposing, manipulating, and reconfiguring dynamical matrices to quickly and reliably compute spectra for multiple defect geometries. Defective spectra were computed through simple, linear operations to the dynamical matrices of pristine lattices. Through matrix decomposition, it is possible to isolate defect contributions into linear operators, resulting in increased computability. Currently, we have developed operators for a 2-dimensional, square, harmonic lattice, and plan to extend the theory to other geometries and anharmonic interactions.

I wish to acknowledge the mentorship of Professor Peter Chung. In addition, she would like to thank Dr Madan Dubey, Dr Raju Namburu, and the nanoelectronics team for their counsel and support throughout this internship.

ADMNSTR
DEFNS TECHL INFO CTR
ATTN DTIC OCP

US ARMY RSRCH LAB
ATTN RDRL CIO LL TECHL LIB
ATTN IMAL HRA MAIL & RECORDS MGMT
ATTN RDRL DP ISABEL LLERENA
ATTN RDRL WML B ROSE PESCE-RODRIGUEZ

INTENTIONALLY LEFT BLANK.