AFRL
FIGHT'S ON!
THE AIR FORCE RESEARCH LABORATORY
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SUMMER 2024

RHW Summer Research Programs

Each summer, students and schools from across Ohio and the nation collaborate with the Warfighter Interactions and Readiness Division through research and internship programs. These programs are a great opportunity for interns, students, and researchers to gain invaluable experience, further the scientific community, and provide valuable contributions to today's (and tomorrow's) warfighters. The articles in this issue of *Fight's On!* highlight only a few of the exciting projects and developments achieved this summer.

Dr. Elizabeth Fox and Erin Silvas examine testing equipment in the VOice Communication Research and Evaluation System (VOCRES) Lab.

Cognition and Modeling

Erin Silvas, a master's student at University of Texas at San Antonio, is a Repperger summer intern being mentored by Dr. Elizabeth Fox in the Cognition and Modeling Branch 711HPW/RHWEM. Erin is contributing to the Neurocognitive Estimation of Real-Time Decision-Making for Human-Autonomy Teaming project. Adaptive displays and autonomous systems of today can utilize predictions of neural activity and performance-based mathematical models, but they are not yet equipped with awareness regarding how an operator is making decisions and how that process may change over time. In this work, neural and mathematical techniques are leveraged to capture the dynamics of decision-making processes over time with computational ease. Model results will serve as input for an adaptive system with the aim to optimize multitasking throughput and processing efficiency. Erin reports research updates in weekly meetings, participates in team-based research efforts, takes an active role in designing/conducting experiments, and will share her contribution to Wing and Division researchers and leadership.

Emily Conway poses with some of her Wright Scholars.

Collaborative Technologies

Despite recent rapid advancements in machine learning (ML) and artificial intelligence (AI), human-machine teaming is strained through ineffective communication and undigestible information overload. This summer, seven interns worked to support two efforts aimed at addressing these challenges, *Tailored Expressive Dialogue System (TEDS) and Contextualized Communication and Machine Learning (CCML)*. In support of TEDS, undergraduate students Samuel Hoppenworth and Palash Goyal, as well as high school student Navya Garg delved into passive methods of stress detection from written communications through machine learning methods. To address the stress detected, high school students Rachel Ku and Navya Garg researched several stress mitigation strategies to improve communications. Rachel then implemented these strategies in the best performing commercial large language models (LLMs) for evaluation. Lastly, high school student Selini Ranatunga researched effective communication strategies for positive cross-cultural communication and justified her findings through statistical analysis of foreign conversations.

To support CCML efforts, master's student Andrew Lee and high school student John Campbell worked with a large audio-visual dataset. John automatically scraped all relevant textual data from metadata and transcriptions which populated an investigative tool he built. This allowed users to search and watch the dynamic between subjects change over time. Concurrently, Andrew trained vision-language models to extract visual information absent from the transcript to complete the contextual temporal report of the data.

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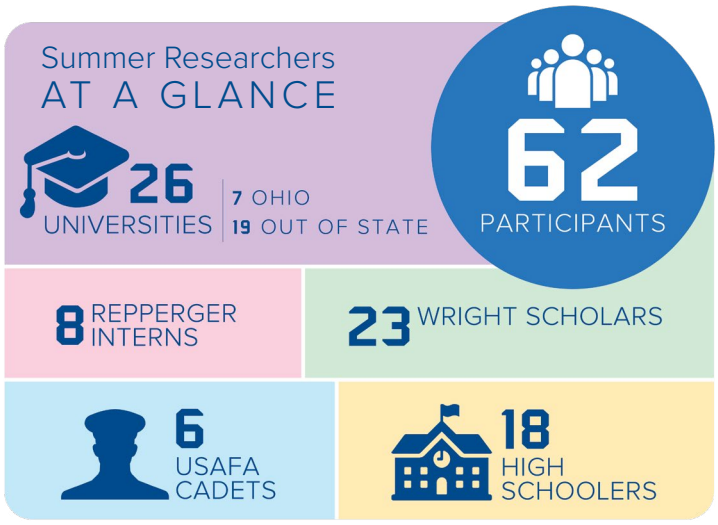
INSIDE THIS ISSUE

Operational Learning Sciences

Under the mentorship of Dr. Jayde King, Lan Li and Yolanda Xie are studying the actions, strategies, decision-making processes, and tools used to complete cognitively demanding tasks. Throughout their ten-week internship, they conducted a cognitive task analysis through observing satellite passes and interviewing satellite operators. This was used to inform the creation of a set of task mental model requirements and a human- and machine-readable representation format for task knowledge. This project is in collaboration with RV at Kirtland Air Force Base where another intern, Ashley Bishop, (mentored by Ms. Michelle Simon) is developing an autonomous pipeline for task mental model elicitation using natural language processing. By studying human teams in complex task scenarios, the goal of this project is to get a step closer to the human-AI teams of the future. After completing their work, Lan and Yolanda will present their findings to RHW members and leadership during the Chief Scientist Poster Session.



Warfighter Interfaces

Ashley Millard, a PhD student at Texas Tech University, is studying the use of physiological and behavioral data to aid control transfers in human-machine teams. Under the mentorship of Dr. James Bliss, Senior Research Psychologist, Ashley's work with closed-loop human-automation interaction adaptation is investigating best practices for adaptive aiding techniques, including when and how transfers of control should occur to improve performance and control transfer in human-machine teams. Adaptive automation allows for real time adaptive aiding based on user states that can be determined by techniques such as cognitive modeling, performance, or physiological data. For example, adaptive aiding can mitigate the effects of static automation use including loss of situational awareness, loss of vigilance, and additional workload. Ashley's study will determine the best interface designs and automation transfer techniques to improve warfighter effectiveness before detrimental performance declines occur. Her efforts are a promising approach to improving Intelligence, Surveillance, and Reconnaissance (ISR) task performance. ☆

Mr. Dave Hubbell, Sr. Technical Writer, CAE USA

All photos by Mr. Will Graver (BAE Systems, Inc.)

Dr. Jayde King collaborates with interns Lan Li and Yolanda Xie.

RHW RECOGNITIONS

2nd QUARTER AWARDS

AFRL
- Laboratory Scientist of the Quarter: **Dr. John "Chris" Brill**

RH
- Civilian Category II: **Jim Howard**
- Lance P. Sijan USAF Leadership Award: **MSgt Matthew Boland**

RHW
- Company Grade Officer: **2Lt Seth Bohn**
- Field Grade Officer: **Maj Matthew Fagan**
- Civilian Category III: **Dr. Lorraine Borghetti**
- Collaboration: **Steven "Conner" Campbell**
- Non-Commissioned Officer: **TSgt Joel Dumont**

Air Force Intelligence, Surveillance and Reconnaissance Awards Program (AFISRAP)

711 HPW
- ISR Deployed Officer: **1Lt Ryan L. Lechich**
- RegAF ISR NCO: **TSgt Joel B. Dumont**
- RegAF ISR FGO: **Maj Matthew D. Fagan**
- RegAF Officer: **Capt Grace L. Hall**
- ISR Unit: **711 HPW Wing Intelligence Team; RHWI**

Hails

Dean Berry
Catherine Bui
2Lt Kyle Cruz
Capt Daniel Cunningham
2Lt Michael Dillon
Maj Jade Driggs
SSgt Aaron Elmore
Dr. Jordan Haggit
Capt Grace Hall
1Lt Matthew Kinneer
Lt Ryan Lechich
Dr. Molly Liechty
Lt Arianna Martinez
TSgt Gregory Mayer
Ariel Molnar
2Lt Alma Payan
Gregory Rupert
Capt Jessica Shelving
Maj Christopher Stephen
MSgt Ryan Swindlehurst
Capt Lukas Texeira
Kayelin Tiggs
Lt Alexandra Weisenburger
Col Michael Zollars

Farewells

MSgt Matthew Boland
Lt Joshua Broekhuijsen
S. Conner Campbell
Capt Venessanna Deppermann
Lt Griffin Keune
Sam Kuper
Capt Eric Lawson
Capt Daniel Liszka
Lt Tevin Miller
Lt Col Matthew Moye
Dr. Taylor Murphy
TSgt Andrew Pauldine
Capt Marshall Quebatay
Col Alfredo Rivera
Matthew Scharf
Ben Steinhauer
Lt Col Christopher Terpening
Capt Jonathan Turner

MAY - AUGUST 2024

Summer
AT THE GRILL®

Wright Scholars
High School 11
Undergraduates 8

USAFA Cadets 5

Teachers 6

SOCHE Interns 3

Undergrad Interns 1

Legacy HS 1

Summer Researchers 2

Challenge Problems

Extended Reality Laser Dazzle Shooting Simulator

An XR shooting task is in development that evaluates the impact of laser dazzle on warfighters in urban settings in different light conditions. This will include threat and distraction targets, measuring cognitive decision-making, target accuracy, and reaction times. Collaboration with the Bioeffects Division will integrate their Unity-based laser dazzle effects to enhance realism and provide expert guidance.

Immersive Aerial Refueling (AR) with Various Receivers

This project features a simulated model tanker (KC-46 or KC-135) from an Aerial Refueling Operator's (ARO) perspective with the ability to interchange receivers (F-16, A-10, C-17). Receivers are modeled with different behaviors such as fast/slow approach, unstable, and can react to commands with plans to implement different weather conditions and backgrounds.

Night Vision Displays and Performance Impediments During Live-Fire Scenarios

The team is creating a VR simulation of Airmen conducting urban warfare maneuvers at night, including ingress, clearing, and egress of a building. It features three types of NVG displays (green phosphor, white phosphor, and thermal), realistic obstacles, and performance assessment based on enemy targets eliminated and completion time across several phases.

SkyCargo Express

The project involves managing drone deliveries across diverse locations with a focus on coordinating multiple drones and ground vehicles. Controllers use a point-and-click interface, incorporating features like play calling and speech-to-text asset control while utilizing visual displays ranging from clean maps to cluttered satellite imagery for situational awareness and decision-making.

Team Situation-Awareness for Watchstanders

Navy Watchstander teams monitor maritime environments to prevent collisions, focusing on vessels' closest points of approach (CPA) as a key metric for threat assessment. This augmented reality (AR) system tracks and alerts the team if insufficient attention is given to vessels with close CPAs. The system simulates the maritime environment, uses head and eye tracking to monitor focus, and employs an algorithm to ensure critical objects receive adequate attention from users.

Virtual Leadership Reaction Course – Multi-Player Educational Role-Playing Game (MPERPG)

The Air Force is utilizing gaming concepts to create a virtual leadership reaction course where Airmen and Guardians can practice leadership behaviors. With advancements in VR and gaming technology like Unreal Engine, these simulations are now in first-person perspective, enabling realistic interaction among up to five participants to enhance skills such as collaboration, decisiveness, and accountability in virtual scenarios.

Cadets Develop Land Engagement Adjudication Interface

Five US Air Force Academy cadets have achieved a significant advancement for cadet military education at their service academy by reimagining a crucial war-gaming interface at the AFRL's Gaming Research and Integration for Learning Laboratory® (GRILL®).

The cadets developed an enhancement to the existing wargame platform allowing young warfighters to study pivotal tactics of land-based engagements instead of using dice. This top-down development aims to enhance training simulations crucial for strategic planning and decision-making at USAFA's Multi-Domain Laboratory, a purpose-built room where cadets learn about the joint warfighting environment. Jerry Huggins, one of the software engineers at the GRILL added that "The cadets' resourcefulness and teamwork was on full display each day as they developed this new training tool. I'm continually impressed by their dedication to furthering strategic competency for future cadets."

The new interface called the Land Engagement Adjudication Platform, LEAP, will adjudicate land engagements by processing mathematical models from real cadet-provided tactics. Instructors in the Academy's Military Strategic Studies department are confident this new solution will achieve Institutional Outcomes of employment of U.S. National Security Strategy in a Complex Global Environment and Organizational Leadership for cadets that use LEAP.

"Their work represents a leap forward in our ability to simulate complex battlefield scenarios to train the next generation of warfighters."

-Capt. Eric Lawson, GRILL PM

The cadets' achievement underscores the Air Force's commitment to leveraging emerging technologies and the creative potential of its personnel. Their success at the GRILL highlights the vital role of research and innovation in maintaining military readiness and superiority in an increasingly complex global security environment. ☆

Mr. Luke Kuklis, United States Air Force Academy Cadet

INTERNATIONAL COLLABORATIONS

Components of Complex Decision Making

Perception, cognition, and action require the coordination of neurons; therefore, it is crucial to understand the basic mechanisms by which neural circuits interact across the brain and how those interactions give rise to cognitive processes and behavior. Neural recordings with high temporal resolution such as electro-encephalography (EEG) can be very useful to extract the nature of these underlying latent processes in decision making. The complication with such procedures is that measuring the onset of cognitive events in these signals is hampered by the fact that relevant activities are usually several orders of magnitude weaker than the background noise; hence, signal averaging over several hundreds of trials is often used to extract reliable signals. Unfortunately, averaging continuous time series across trials is well known to hide and distort single-trial effects.

The European Office of Aerospace Research and Development (EOARD) provides grants to European scientists to conduct cutting-edge basic research in support of USAF priorities. A grant was awarded to University of Groningen (PIs: Jelmer Borst and Leandert van Maanen) to develop an analysis framework that can be used to discover stages in cognitive processing within a single EEG trial. The proposed framework combined hidden semi-Markov models with a multivariate pattern analysis (HsMM-MVPA) and is predicated on the fact that a significant cognitive event is expected to be visible as a transient change in an EEG time-series. It assumes that these transient changes are patterns repeating across all trials in an orderly manner, and that their onsets follow certain distributions. The HsMM-MVPA uses expected time, sequential nature of the patterns and channel contribution to uncover single-trial EEG events. Thus, if detected EEG events and cognitive processes are linked, then resulting HsMM-MVPA can be interpreted as the sequence of cognitive operations that happened on each trial.

There are several important implications for the USAF. First, uncovering these latent processes allows us to examine the building blocks of sequential decision making, thereby attaining a “fingerprint” of different cognitive stages. Second, having “fingerprints” of optimal decision makers or experts will allow us to train airmen and guardians to these standards using objective neural metrics. Lastly, it will allow us to examine the influence of external stressors on decision making. The investigators have visited the lab under a Windows on Science visit and are examining the possibility of an extended visit to the lab, where data collected in the lab can be examined using their model. ☆

Dr. Nandini Iyer, International Program Officer, AFMC AFOSR/IOE

RHW PUBLISHED CONTENT MAY - JULY 2024

JOURNAL PUBLICATIONS

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Nelson, J. (2024). Are Structured Analytic Techniques (SATs) the Missing Component in Cognitive Warfare? The Future of ISR Military Operations. *Human Factors and Systems Interaction, 154.*

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711 HPW/RHW Core Research Areas:

- Digital Models of Cognition
- Distributed Teaming & Communication
- Human-Machine Interactions
- Learning & Operational Training