COLLEGE OF ENGINEERING
BRADLEY DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
VIRGINIA TECH

Project Number: **1**

Project Sponsor:

Aerospace Corp,

Project Title: **AI-based Multi-Sensor Fusion**

SME: tbd

Customer POC: Michael Nemerouf, 310-336-4128,

Given the heavy reliance on GPS for critical military/civilian applications and systems, developing resilient PNT solutions to protect GPS systems from attacks is a high priority for Aerospace and its customers. Robust solutions often involve combining multiple sensor inputs with novel approaches. Fusing IMU and GPS sensor inputs can provide a solution that is substantially more accurate and robust than their individual components. Traditionally, a Kalman filter is used to combine sensor inputs, but this approach is often complicated to implement and requires manual, expert-guided tuning. This is a challenge for scalability, automation, and deployment, and we are aiming to develop a machine learning-based approach to overcome these barriers to implementation.

This project will involve developing a machine learning model that emulates the function of a standard Kalman filter. This will be a supervised learning task (regression), in which the model takes in GPS+IMU measurements as inputs and learns to output the truth position. This will be the first step in developing a ML-based sensor fusion implementation that meets/exceeds a standard Kalman filter in terms of accuracy and throughput. The deliverable will be a report detailing a machine learning model architecture (implemented in industry standard frameworks such as TensorFlow, PyTorch, sklearn, etc.), along with model performance benchmarks (ex. throughput, accuracy) and comparisons against a standard Kalman filter implementation. The final report should also detail the processes behind model architecture selection, data preprocessing, model training, hyperparameter tuning, testing and validation, etc. If time permits, we are also interested in exploring prototypes of an adaptive Kalman filter, in which a machine learning component supplements a standard Kalman filter instead of replacing it. For example, this could be done by training a ML model to adjust the Kalman filter's error covariance matrix in response to the sensor inputs.

NOTES: Project team members need to be US Citizens.

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Project Number: **2**

Project Sponsor:

Aerospace Corp.

Project Title: **Coral Jam' - port existing GPS Anti-Jam ML models to low size, weight, and power (SWaP) platform**

SME: tbd

Customer POC: Michael Nemerouf, 310-336-4128,

Aerospace has machine learning (ML) models developed in-house that, when paired with a software defined radio, allow novel signal processing capabilities. One of these capabilities developed is focused on GPS anti-jam, we have shown that a trained neural network, running in real time, can perform mitigation of a multitude of jammers corrupting a received GPS signal. Our current setup uses ML models running on either multiple GPU servers or small, Jetson single-GPU embedded boards connected to software defined radios. In this collaboration project with VT, we will take existing models trained and developed at Aerospace for use in GPS Anti-Jam and implement them on low size/weight/power (SWaP) devices. Dedicated neural net hardware such as Google Coral USB nodes, paired with commercially available software defined radios will be the initial target. Implementing the entire model running at GPS civilian bandwidths (ie at a high enough sampling rate) may be an interesting project for a group of VT students.

The project may require downsizing or re-factoring our existing ML models through state of the art optimization approaches to enable inference at a high enough bandwidth, and will require the VT collaborators to study engineering tradeoffs such as performance of anti-jam vs ease-of-implementation and SWaP constraints. If not a Coral device, then the VT team will look into other low SWaP options for implementation and report and test on these options. Testing of the anti-jam performance will be measured by downstream GPS receivers which measure the effective SNR (C/No) and location fix. Some scripting will be required of VT to automate laboratory testing of these downstream receivers as well as automation of lab-generated “jammers” which vary their power over time in controlled tests of performance. Thus, the project will provide experience in both machine learning development and practical engineering implementation/test of complex systems.

NOTES: Project team members need to be US Citizens.

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Project Number: **3**

Project Sponsor:

Aerospace Corp.

Project Title: **Satellite Navigation PNT Sensor Algorithm**

SME: tbd

Customer POC: John A Janeski, John.A.Janeski@aero.org,

Autonomous vehicles (e.g. self-driving cars, satellites, UAVs) rely on Position, Navigation and Timing (PNT) systems to determine the vehicle's current position/attitude and time, the next desired position/attitude and the required position, velocity and acceleration corrections needed to get to the desired state. A prior design team developed a low Size, Weight and Power (SWaP) sensor suite for a PNT sensor designed to help a vehicle navigate in through short periods where it's primary PNT system does not have access to Global Navigation Satellite System (GNSS) signals.

The focus of this design effort is to implement the sensor fusion algorithms to form a navigation solution. The design team will be responsible for developing the code needed to ingest data from the PNT sensors, translate the data into the correct coordinate frames, run the provided sensor fusion algorithms and form a navigation solution. The team will also need to characterize both individual sensor performance (required to tune the navigation algorithms) and fused navigation solution performance.

Implement sensor fusion algorithms and characterize a sensor suite that when integrated will provide a navigation solution through maneuvers when integrated into a vehicle. The design effort will mature a prototype developed by previous design teams that implemented an IMU blended with a magnetometer and sun sensors. Additionally, this year's effort will move the sensor one step closer to being integrated onto an Aerospace Small Satellite mission with the implementation of our SatCat5 interface.

Deliverables:

- Fully functional navigation unit that will blend together outputs from multiple sensors to form a position and attitude solution.
- Test procedure and results from characterization of each sensor's performance in a static environment.
- Algorithm to blend sensor outputs into a navigation solution.
- Characterization of the unit's SWAP to ensure it meets requirements provided in Section 3.0

NOTES: Project team members need to be US Citizens.

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Project Number: **4**

Project Sponsor:
ImpruvonHealth
Impruvon Health Corp

Project Title: **Method & Components to Verify Medication Compliance**

SME: tbd

Customer POC: Justin Amoyal, justin@impruvonhealth.com,

Develop embedded component(s) /middleware and integrate with Impruvon Health's existing medication management hardware.

This is a great opportunity for students interested in utilizing their engineering knowledge/education to innovate and drive much needed health related impacts such as stopping overdoses. The component(s) developed shall detect intentional access attempts such as a medication theft as well as 'accidental' access attempts such as a curious 2-year-old mistaking medications for candy. Once the unauthorized access attempt is detected a notification shall be sent to an authorized user's mobile device to alert and/or authenticate the attempt.

Product Impacts

- Stop medication thefts
- Prevent intentional drug abuse / over-doses
- Prevent accidental medication digestion
- Immediate awareness to enable intervention, and
- prevent the addiction cycle from progressing

Discovery / Brainstorming

- COTS Components to expedite
- Trade-off Questions
- Environmental Concerns
- Requirement Definition

Minimally Viable Product (MVP)

- Component down selection
- Project Roadmap with milestones
- Stand-alone working MVP

Prototype

- Data model development
- Black-box integration (integrated with "a back-end" not ours)
- Noise Avoidance Algorithms (V1)

Stretch Goals - Integrated Components

- Integrated with our back end
- Controlled via mobile and web app
- Noise Avoidance Algorithms (V2)

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Project Number: **5**

Project Sponsor:
ImpruvonHealth
Impruvon Health Corp

Project Title: **Medication Theft Detection & Real-time Alerts**

SME: tbd

Customer POC: Justin Amoyal, justin@impruvonhealth.com,

Develop embedded component(s) middleware and integrate with Impruvon Health's existing medication management hardware.

This is a great opportunity for students interested in utilizing their engineering knowledge/education to innovate and drive much needed healthrelated impacts such as stopping overdoses. The component(s) developed shall detect intentional access attempts such as a medication theft as well as 'accidental' access attempts such as a curious 2 year old mistaking medications for candy.

Once the unauthorized access attempt is detected a notification shall be sent to an authorized user's mobile device to alert and/or authenticate the attempt. Deliverables listed below.

Discovery / Brainstorming
- COTS Components to expedite
- Trade-off Questions
- Environmental Concerns
- Requirement Definition

Minimally Viable Product (MVP)
- Component Down-select
- Project Roadmap with milestones
- Stand-alone working MVP

Prototype
- Data model development
- Black-box integration (integrated with "a back-end" not ours)
- Noise Avoidance Algorithms (V1)

Integrated Components
- Integrated with our back-end
- Controlled via mobile and web app
- Noise Avoidance Algorithms (V2)

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Project Number: **6**

Project Sponsor:

JUMP CRYPTO

Jump Trading

Project Title: **Helium LoRaWAN antenna selection software for Jump Crypto network**

SME: tbd

Customer POC: Andrew Millard, amillard@jumptrading.com,

Jump Crypto has been partnering, innovating and trading in the crypto world for years. Our aim is to help lay down the pavers and conduit that will shape the future of the industry. In support of this mission and to foster the expansion of the Helium network, the project team will create a software model for predicting the coverage and expected mining return of a Helium LoRaWAN node at a given location/antenna configuration. The goal of the project is to provide the Helium community with open-source tools to better evaluate the coverage and profitability of potential locations for network hotspots.

The project team will create a software model for predicting the coverage and expected mining return of a Helium LoRaWAN node at a given location/antenna configuration. The model will allow node operators to assess the coverage a new node would provide and the expected mining return.

The deliverables for this project are:

- A software model estimating which existing nodes can be “seen” from a given location, height, antenna gain. The tool is expected to utilize an open-source link budget/coverage analysis tool such as Splat to perform this analysis
- A software model for estimating mining output based on Helium network mining reward specifications
- Documentation deliverables
  - o Committed source code in public Github
  - o Documented setup and use of the developed tools
  - o Report comparing predicted coverage/earnings vs observed for existing Helium nodes to validate model accuracy
  - o Summary report for publication on the Jump Crypto blog
- On-site design review in Jump’s Chicago office (April 2022) to department leadership and survey of potential node install locations at existing Jump wireless sites in the area

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Project Number: **7**

Project Sponsor:
NORTHROP GRUMMAN
Northrup Grumman, Space Systems

Project Title: **Space Systems Circuit Design & Testing**

SME: tbd

Customer POC: Randy Spicer, randy.spicer@ngc.com,

Based on team skills, will solve one of these challenges:

1) Circuits for controlling torque rod current in two directions. The circuit will need to handle the high inductance for the torque rod and associated back EMF. Microcontroller would need to PWM the torque rod for precise control.

2) Circuits for controlling a motor in a vacuum. Circuit should support 2-phase stepper motors. Ideally the board should include support for up to six individual motors that are controlled with a microcontroller.

Coordinate with Space@VT for use of Varago microcontroller development board. Students will conduct some level of envrionmental resilience testing with the Varago for each of the circuits #1 and #2 above, especially during radiation testing (if coordination can be achieved). The Varago dev board is like $40k, so I'd envision the students build a daughterboard that can interface with any microcontroller so the students can test things out and then have Space@VT support with the Varago hardware. Regardless of what microcontroller is used, it the students design should include software for radiation mitigation (memory scrubbing, watchdog timers, configuration register refreshes, etc). At a minimum, some of these items need to be included in the implementation.

NOTES: Project team members need to be US Citizens.

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Project Number: **8**

Project Sponsor:

pwc
Pricewaterhouse

Project Title: **Improve the PWC Scanning Rigg as part of the Indoor Geo-Location Platform (IGP)**

SME: tbd

Customer POC: Brian Dunch, brian.dunch@pwc.com,

PwC's patented Indoor Geo-location Platform (IGP) is our most broadly deployed Internet of Things (IoT) solution. It has been adopted predominantly by the hospitality industry (e.g., Hotels and Casinos) to protect workers using our Rapid Response Button (RRB), a wearable device. When workers feel unsafe, they can trigger the RRB to alert security staff to the exact location of the worker who triggered the RRB with no need for additional infrastructure such as repeaters or beacons. IGP also can support additional solutions such as asset trackers, gauge readers, door open/close sensors, etc. To implement this beacon-less solution we use a scanning rigg to capture the ambient RF signals to uniquely identify a space as a "scanned location." Our team is interested in designs to improve the scanning rigg. Improvements can be characterized in several dimensions, including signal sensing fidelity, durability, usability, transportability, cost, and others

If we can improve the scanning rigg, we will increase the quality of the signals scanned so we can increase location accuracy. We also will improve our deployment productivity. Finally, we will reduce the cost to build and sustain our scanning riggs and our systems will be more cost effective.

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Project Number: **9**

Project Sponsor:
ece
BRADLEY DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING
VT ECE

Project Title: **Swing stabilization for sling loads and hoists for helicopters**

SME: Mary Lanzerotti

Customer POC: Mary Lanzerotti, marylanzerotti@vt.edu,

There is a need for a mechanical stabilization system for low-mass sling loads in medical evacuation (MEDEVAC) helicopter rescues. Such a system has potential for integration for use by Black Hawk helicopters in the U.S. Army. Breeze-Eastern LLC manufactures the hoists on Black Hawk helicopters used in the U.S. Army. Collaborators also include an expert in nonlinear dynamics who is a faculty member at Sapienza University in Rome, Italy as well as a faculty in the Virginia Tech Research Center in Arlington, VA. The main objective of this project is to develop a mechanical stabilization system for a low-mass sling load. Additional objectives are to build a prototype of the system in simulation and in hardware. Testing and characterizing the prototype sytstem is a final goal for the current project.

Participating students will design, model and implement a few stabilization control methods with the long-term goal to demonstrate that the load is stabilized. Students will have the opportunity to read the literature developed by previous cadets, model the problem, develop creative approaches, perform engineering trade-off analyses, and incorporate realistic constraints (see Section 3.0 of the project request form) in their designs. Students will document their work during the course of the semester and will communicate their work to their sponsors and peers. Machine learning approaches to optimize the stabilization are welcome.

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Project Number: **10**

Project Sponsor:

Collins Aerospace

Collins Aerospace

Project Title: **Health monitoring of power electronic converters**

SME: tbd

Customer POC: Debabrata Pal, Debabrata.pal@collins.com,

The student team will study the various approaches of determining prognosticative health monitoring methods for power electronic converters. Perform analysis of a power converter components in use and determine what sensor information can be correlated to predictive maintenance. Identify and recommend useful measured parameters such as change in voltage, current, noise, frequency, temperature etc for their use as prognosticative indication of failure. Develop a tool to demonstrate and illustrate your results.

NOTES: Project team members need to be US Citizens.

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Project Number: **11**

Project Sponsor:

Collins Aerospace

Collins Aerospace

Project Title: **Search-and-Rescue Swarm Robotics**

SME: tbd

Customer POC: Stefano Riverso, stefano.riverso@collins.com,

Distributed cooperative systems have great possiblities to provide value. Search-and-Rescue is one area where a swarm of inexpensive robots can provide excellent value. In this project, we want to consider several alternatives for robot S&R swarms to assist humans in critical operations. This team will produce a document which indentifies, at least, four use cases for a swarm of 4-8 robots to interact with a human operator to improve search and rescue operations. The students will propose metrics to differentiate the value proposition and will work with the customer to select the criteria. This will be used to downselect from all alternatives to one use case to build, test, and evaluate.

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Project Number: **12**

Project Sponsor:

Collins Aerospace

Collins Aerospace (possible)

Project Title: **Composite structures damage detection with ML**

SME: tbd

Customer POC: Steven Kestler, Steven.kestler@collins.com,

Damage detection on composite structures is critical to the development of condition-based maintenance planning. Normal composite structures are designed for life of an aircraft, however, damage from foreign objects can cause delamination, punctures, or cosmetic damage. Damage detection can reduce inspection time for structures. These students will either receive characteristic datasets or will synthesize an appropriate dataset (and document their assumptions) to develop and evaluate a machine learning (ML) approach to damage detection of composite structures.

NOTES: Project team members need to be US Citizens.

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Project Number: **13**

Project Sponsor:

Collins Aerospace

VT ECE

Project Title: **Interactive ECE Degree Planner, phase 2**

SME: Bill Plymale

Customer POC: Mary Brewer, taylorm@vt.edu,

Create a tool that provides a centralized location for students to be able to access various degree planning services. The tool will allow stakeholders to view all of the available ECE courses, create and test plans of study through DARS/HokieGPS, access links to the ECE website, and more. In short, the tool will provide a central location where students can access the most important tools they need in order to make decisions regarding their studies here at Virginia Tech. In addition, the tool will allow for the advisors to easily add or update information as needed. Stakeholders in this project are potential ECE students, incoming ECE students, current ECE students, and ECE advisors.

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Bill Plymale, plymale@vt.edu

Plymale.

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Project Number: **14**

Project Sponsor:

HUME CENTER FOR NATIONAL SECURITY AND TECHNOLOGY
VIRGINIA TECH

VT Hume

Project Title: **Use & Abuse of Personal Information**

SME: Alan Michaels

Customer POC: Alan Michaels, ajm@vt.edu,

Our personal information goes everywhere! Over the past two years, researchers at the VT National Security Institute have been investigating how personal information propagates around the Internet, with the intent to conclusively link the use of personal information in every-day transactions and the subsequent sharing, leakage, or otherwise misuse of that information. A core part of this effort is the development of tools to (1) automate the generation and database storage of fake identities with realistic / representative personal information, (2) anonymize and/or precisely control browser settings/signatures, IP addresses, and synthesize false browsing histories, (3) accelerate the manual signup process for a diverse set of something like 10,000 websites, (4) stimulate falsified activity for received email traffic to emulate a real user opening and consuming the data, (5) improve reception, filtering, and automated collection of email traffic using a RainLoop (or equivalent) server, (6) develop automated tools to [safely!] analyze and catalog received emails for malicious content, and (7) extend open source and custom tools (basic analytics and machine learning) to categorize contents of the received data (email, voicemail, texts) to help answer multi-disciplinary research questions. Testing these tools will be facilitated with an existing dataset of nearly 20,000 items from a previous small-scale experiment.

Students will gain familiarity with the Use & Abuse experiment, and then dive into a review of existing tools that results in a prioritized list of tools for development. Students will identify the prevailing tracking/sharing mechanisms used by companies, cybersecurity threats associated with malicious content, and ultimately develop and demonstrate a suite of tools that address these challenges. Documentation will include a final report with intent to submit to a conference. Further, while students will have unique responsibility for their identified automations tools (to be negotiated with project sponsor), students will perform their research in tandem with a heavily multi-disciplinary research team that is working towards the full-scale experiment in 2023. Prior experience in cybersecurity-oriented programming (team-based coding projects, Linux-based code development), web tools (website design and security, Tor), databases (mongoDB, mySQL, MS Access, etc) and/or strong interest in testing hypotheses across a range of potential research questions is desired. Further, participation in this project will require access to active engagement with that larger team that meets in an ITAR/DFAR-restricted facility at the VT National Security Institute, so all participants must be U.S. citizens & attend OESRC Restricted Research training & sign a Technology Control Plan (TCP).

NOTES: Project team members need to be US Citizens.

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Project Number: **15**

Project Sponsor:
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BRADLEY DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING
VT ECE

Project Title: **Design, Development, and Evaluation of Control Algorithms for Spectrum-Sharing Wireless Communication Links**

SME: Carl Dietric

Customer POC: Carl Dietrich, cdietric@vt.edu,

A team of students will design, develop, and evaluate multiple control algorithms for wireless communication links that share frequency spectrum. The team will coordinate with the customer's organization to determine which spectrum or system characteristics should be consisdered to either inform decisions or should be managed using the decisions.

- Identify promising approaches for adaptive and/or predictive control of flexible configurable wireless communication transmitters
- Implement several adaptive/machine learning control algorithms based on the selected approaches
- Design, perform, and analyze data from experiments that use a simulation environment to measure the algorithms' performance in complex shared radio frequency environments
- Present results recommending an algorithm, and making recommendations for future work based on what you learned during the project.

Stretch goals for this project include modifying the simulation environment so that the control algorithms can be implemented in Python instead of JavaScript, and repeating the experiments using software defined radio hardware.

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