2023 RI Summer Internship Program

Research Topics

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Research Project Topics

The mission of the RI Intern Program is

- *Cultivate and develop future research scientists and engineers in Command, Control, Communications, Computers, Intelligence (C4I) and Cyber Technologies*
- *Provide mentor-led projects to assist the mentor and empower the intern to discover, develop, and expand their professional talents*
- *Recruitment of talented and motivated students for summer internships and co-op positions*
- *Expand the Interns skillset through Enrichment Sessions, advocate graduating interns as potential hires, and facilitate a buddy system to stay connected with the interns*

How to Use This Document:

The projects on the following pages detail potential opportunities for internship at the AFRL Information Directorate for summer 2023. Please review the projects and preferred skills of each project, and feel free to email any questions to intern@griffissinstitute.org. Please reference the name of the project when asking questions.

When applying to the internship program, please select any and all projects that you would like to be considered for.

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Topics are listed by the Information Directorate Division of the Lead Scientist

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Research Project Topics

Intelligence Systems Division (RIE)

Implementation of an Intuitive Augmented Reality User Interface for Data Interaction

The Three-Dimensional LiDAR Information Visualization and Exploitation (3DLIVE) project aims to create a new system of interaction with 3D point cloud data (primarily LiDAR collects) for targeting tasks such as Precise Point Mensuration (PPM) and Battle Damage Assessment (BDA). A major component of the 3DLIVE project is an Augmented Reality (AR) interaction system that would allow a targeteer to select precise points and measure distances on point cloud data within an intuitive three-dimensional space projected onto the real world. Such a system requires an easy to use and intuitive user interface (UI) that allows the user to select options to switch interaction modes as well as control the way the data and metadata is displayed.

An intuitive AR UI would be displayed in front of the user in the augmented world, following either the user's gaze or hand. There would be a main menu with buttons that can be pushed with a finger to lead to submenus for interaction modes, metadata, measurement info, and point display options. Every button, input box, and radial/slider would be easily visible and interactable by the user and would include easily interpretable visuals alongside text descriptions. The 3DLIVE project is made using the Unity game engine, so the UI would also be designed within this engine (likely utilizing the Mixed Reality Toolkit Unity Plugin).

Task: The task would involve brainstorming an idea for an Augmented Reality User Interface meeting the 3DLIVE project's requirements for interaction with point cloud data, and then implementing this design within the project using the Unity game engine.

Skills Preferred Include: This task will require knowledge of UI design and the C# programming language; however, these topics can be learned during the task. Knowledge of Unity and some sort of modeling engine like Blender would be beneficial.

Advanced Analytics and Exploitation of Space Situational Awareness Data

Space Situational Awareness requires maintaining knowledge of all activities in the space domain at all times. As space becomes more congested it is necessary to collect more data for space object tracking and characterization. This results in large volumes of disparate data from a variety of sources. As such, automated tools are needed to process this data. Specifically, we seek to develop methods to autonomously identify and characterize space-based threats. These may be physics-based algorithms such as maneuver detection methods and conjunction prediction and assessment methods, as well as machine learning methods to identify complex patterns-of-life for space objects. The focus of this topic is to develop or improve methodologies to detect, track, and identify space objects, identify and assess threats, characterize and assess the impact of events, and evaluate courses of action for response.

Tasks:

- Familiarizing with satellite motion, orbital dynamics, and space data sources.
- Development of techniques, methodologies, or algorithms to support Space Situational Awareness goals to be determined by candidate experience, background, and research interests
- Application of work to and evaluation against real-world data and scenarios

Skills Preferred Include: The project will require a working knowledge of physics, familiarity with satellite motion and programming experience in relevant language (e.g. MATLAB, Python) or proficiency in tools such as STK or AFSIM

CAD Modeling of Space Surveillance Telescopes

In order to maintain a complete knowledge of the population of objects in space, each object must be routinely observed to allow their orbits to be determined and updated. Observation and tracking rely primarily on ground-based sensors, including radar and electro-optical sensors such as telescopes. The most common method by which geostationary satellites are tracked is optically – i.e., through telescopes. The objective of this topic is to generate a library of CAD models of telescopes and observatory domes suitable for space surveillance, in such a manner that their configurations can readily be changed. Various commercial-off-the-shelf telescopes will be modeled. Depending on the outcomes of this, extensions such as generating images of the sensors using computer vision software, or 3D printing the models, may be pursued.

Tasks:

- Identification of key features of telescopes and observatories to be modeled
- Identification of commercial off-the-shelf hardware to be modeled
- Modeling of telescopes and observatories based on available information (images of telescopes and/or domes, published dimensions, etc)
- Potential for image generation of sensors using computer vision software (e.g., Blender)
- Potential for 3D printing of models

Skills Preferred Include: Knowledge of CAD modeling

Hard and Soft Data Fusion for Space Object and Event Characterization

The overarching goal of all Artificial Intelligence/Machine Learning (AI/ML) is to develop systems that understand, think, learn, and behave like humans. Essentially, they are trying to represent concepts on a level equivalent to how the human mind thinks. Unfortunately, most traditional AI techniques fall short of this goal and are not capable of accurate concept identification. A new and emergent technique for represent how the human mind perceives concepts has been developed coined Conceptual Spaces. Conceptual Spaces hold the ability to integrate data that is easily quantifiable “hard” data, which usually comes in the form of measurements, and less easily quantified “soft” data, which can come in many different forms such as intelligent reports or intuition. The reason most AI/ML techniques fall short of their goal is because they are not implementing the soft data that is critical to human decision making.

Unlike traditional AI/ML, Conceptual Spaces build a conceptual layer that can be modified and adapted for appropriate concept identification. Conceptual Spaces are advantageous because they can incorporate soft data. Hard and soft data is especially useful in the Space domain for Space Situational Awareness (SSA) and Space Domain Awareness (SDA). Currently, soft data is being underutilized, our goal is to develop a technique that can facilitate both the hard and soft data for concept and event characterization of space-based assets.

Tasks:

- Familiarization with Conceptual Spaces and linear integer programming
- Build Conceptual Spaces models for space objects and space events
- Implement machine learning techniques for conceptual spaces building and property identification

Skills Preferred Include: Proficiency in the following: Computer Programing, Python, MATLAB. Working knowledge of computer programming, optimization, and mathematics. A background in space systems, cognitive modeling, and machine learning is preferred but not necessary.

Modeling Cyber-Attacks for Non-Kinetic Wargaming

The increased integration of information technology, operational technology, and renewable energy resources in power grids have led to new operation challenges. Cyber-attacks could affect the reliability, safety, and resilience of a power grid. The goal of this intern data call is to introduce summer interns to modeling and analyzing the impact of cyber-attacks in a power grid. The results of this data call will allow implementing the cyber-attacks component for the Phantom Arrow War Game.

The Phantom Arrow Wargame is an RI in-house wargame effort currently based on the commercially available wargame Persian Incursion. The wargame itself is designed in the Unity Game Engine with the C# programming language. The energy system designed from this effort and model for disruptions to the power grid would be an additional feature to incorporate into the wargame to provide an additional attack vector for Blue and Red forces to consider. This incorporation would most likely be simply based on the output from the disruption effort, i.e., the grid produces X power at 100%, Y power at 85% (under attack), etc. to be a more simplified model to allow for non-kinetic/cyber-attacks in the Phantom Arrow War Game.

Tasks

- Getting familiar with the Phantom Arrow War Game, surveying Power Grid Cyber-attacks, and completing MATLAB online courses
- Modeling a power grid system
- Analyzing the effects of a cyber-attack and categorizing cyber-attacks using a heat map
- Output from mathematical model of cyber-attack simplified to allow for representation in Phantom Arrow Wargame

Skills Preferred Include: Basic knowledge of MATLAB and Simulink (Desired but not required). Also, MATLAB/Simulink Student Version.

Automated Characterization of Satellite Rendezvous & Proximity Operations

Space Situational Awareness requires maintaining knowledge of all activities in the space domain at all times. As space becomes increasingly congested, automated methods to characterize and identify satellite motion are needed. One particular area of interest is that of satellites engaging in proximity operations, where one or more satellites are moving relative to a target. This effort seeks to develop methods to automatically process spacecraft orbit data and categorize relative motion based on pre-defined classes. Criteria will be sought by which motion classes can be distinctly identified, and an algorithm will be implemented to classify motion. Different algorithms may be developed and tested, including but not limited to decision trees, multiple-hypothesis methods, and conceptual spaces.

Tasks

- Familiarizing with satellite proximity operations modeling, including Hill Frame coordinates and Clohessy-Wiltshire equations.
- Simulating satellite proximity operations and maneuvers.
- Definition of unique criteria that define different motion classes.
- Development of an algorithm or algorithms that categorize proximity operations based on said criteria.

Skills Preferred Include: Knowledge of orbital dynamics and programming experience in relevant language (e.g. MATLAB, Python)

Short-Arc Initial Orbit Determination for Low Earth Orbit Targets

When new objects are discovered or lost objects rediscovered in Low Earth Orbit (LEO), very short arcs are obtained due to limited pass durations and geometrical constraints. This results in a wide range of feasible orbit solutions that may well-approximate the measurements. Addition of a second tracklet obtained a short time later – about a quarter of the orbit period or more – leads to substantially improved orbit estimates. However, the orbit estimates obtained from performing traditional Initial Orbit Determination (IOD) methods on these tracklets are often insufficient to reacquire the object from a different sensor a short time later, resulting in an inability to gain custody of the object. Existing research in this area has applied admissible regions and multi-hypothesis tracking to constrain the solutions and evaluate candidate orbits. These methods have been primarily applied to Medium Earth Orbit and Geostationary Orbit and have aimed to decrease the total uncertainty in the orbit states. The objective of this topic is to research and develop methods to minimize propagated measurement uncertainty for LEO objects at future times, as opposed to minimizing the orbit state uncertainty over the observed tracklet. This will improve the ability to reacquire the object over the course of the following orbit or orbits to form another tracklet, which will result in substantially better orbit solutions. Sensor tasking approaches which maximize the likelihood of re-acquisition are also of interest.

Tasks

- Familiarizing with classical orbit determination methods
- Simulating satellite orbits, maneuvers, and ground observations
- Formulation and testing of propagation models and sensor tasking to optimize probability of re-acquisition

Skills Preferred Include: Knowledge of orbital dynamics, familiarity with optimization and programming experience in relevant language (e.g. MATLAB, Python).

Information Exploitation and Operations (RIG)

Internet of Things Living Lab

AFRL/RI is in the process of setting up an Internet of Things (IoT) Living Lab (IoTLL), which will be located in the Innovare Advancement Center (IAC). The IoTLL will be a device and infrastructure test ecosystem that will provide security, interoperability, resilience, and data governance opportunities for AFRL/RI and other entities with IoT interest. Typical summer topics may include software and data analysis, integration of multiple sensors, programming, testing of smart devices within Griffiss Park. Topics may include (though not limited to) foundational use of machine learning/artificial intelligence (AI/ML) for use cases that leverage high performance Cloud and Edge computing resources to address high profile research problems areas requiring novel approaches for big data management, and network data (packet) analysis/device vulnerability testing to support secure (compliant) IoT network architectures.

Skills Preferred Include:

- Experience (proficiency) with programming languages such as C++, C#.Net / Java, and Python. Basic familiarity using and developing on both Linux and Windows systems.
- Foundational understanding of wireless networking communication/connectivity protocols used for IoT including basic TCP/IP, MQTT, LoRaWAN etc. Basic understanding of Cloud service models is helpful (IaaS, PaaS, SaaS models) for Microsoft Azure and/or Amazon AWS clouds. Familiarity with existing IoT/Smart device/sensors (i.e., cameras, weather stations) and a good understanding of how to access sensors contained in a smart phone are also desired.

Audio & Acoustic Processing

AFRL/RIGC is involved in the research and development of signal processing algorithms with an emphasis on audio and acoustics as the source. A wide spectrum of basic research topics includes channel estimation, signal conditioning, language identification (ID) and dialect ID. In the area of drone detection, the emphasis is on acoustic detection, tracking, acoustic ID, and acoustic beamforming. Typical summer topics addressing these areas may include software development, database design/analysis, signal processing, algorithmic programming, and the application of novel mathematical approaches such as Topological Data Analysis (TDA). We also employ state of the art techniques such as deep neural networks and other machine learning algorithms to pursue solutions for real-time and offline problems.

Skills Preferred Include: Proficiencies in Python, MATLAB, and supporting technical mathematics along with a background in signal processing, knowledge of acoustic and audio principles, and acoustic wave transmission.

ELINT Signal Processing & Data Science

The AFRL/RIGC ELINT programs include onsite/in-house signal generation, capture, and processing capabilities. Anticipated internship activities include signal processing and data science applications. Specific tasking/topics involves radar waveform definition, generation, and collection, as well as feature extraction, clustering, and tagging.

Skills Preferred Include: proficiency in Matlab, Linux, and signal processing exposure.

Machine Learning Interpretability and Explainability

The AFRL/RI RIGC Branch is comprised of mathematicians, physicists, DSP engineers, software engineers, and intelligence operators. This combination of individuals allows them to tackle a wide spectrum of topics from basic research to the challenging aspects of real-time implementation of the results of research efforts. Typical summer topics may include software analysis, database development, programming, machine learning in IOT type systems and sensor data signal detection and processing. The branch interest range over topics linked to increasingly sophisticated techniques in signal detection, characterization, tracking, and classification, all with the goal of signatures via array processing. State of the art techniques such as deep neural networks and other machine learning algorithms are used to pursue solutions for increasing signal exploitation to enable warfighters with significant situational awareness and knowledge. Key to successful development and use of ML techniques is robust knowledge of ML and insights into the inner workings of these systems.

Skills Preferred Include: Proficiency in higher level programming languages (e.g. Matlab, Python, etc.), signal processing knowledge, knowledge of sensor and sensor data principles, and interest in machine learning.

Software Defined Radio and Machine Learning for Exploitation

The AFRL/RI SIGINT (Signal Intelligence) Group would like to transform the traditional methods for encoding, modulating, transmitting, receiving, exploiting, demodulating and decoding the information carried by man-made signals. We are looking for smart, low complexity, efficient, real-time, reliable and multifunctional transceivers and techniques that take advantage of novel signal processing and machine learning methods. We are also interested in extending methods beyond their conventional usages. Typical summer projects include classification, detection, estimation, classification, coding, and other areas of telecommunications applied to hostile and complex environments. The projects are designed to promote brainstorming and allow the student to implement guided solutions or propose and develop their own depending on technical merits.

Skills Preferred Include: Knowledge of software defined radios, high performance computers, programming languages such as Matlab, Python, Keras, and other available open-source tools would assist the student in both research and development.

Small Unmanned Aircraft Systems (C-sUAS)

The AFRL/RI C-sUAS team is comprised of a unique combination of program managers, cybersecurity specialists, hardware/software engineers, UAS flight testing operators, and UAS Traffic Management

(UTM) subject matter experts. This combination of individuals allows them to tackle a wide spectrum of topics including:

- Basic and applied research such as Commercial Off-the-shelf (COTS)
- Small Unmanned Aircraft System (sUAS)
- Command and Control (C2) link exploitation
- sUAS detection/tracking/identification and defeat capability development

UTM capability development for ensuring the safe operation of UAS within the National Airspace System (NAS)

Application of Artificial Intelligence (AI) and Human-Machine Teaming (HMT) to speed up decision making to assist C-sUAS and UTM Operators in executing their missions.

Tasks:

Typical summer tasks may include: C2 protocol analysis, C-sUAS capability development, AI/ML/HMT programming and algorithm development, and UTM capability development. Systems include the Ninja and Paladin C-sUAS systems, and the Collaborative Low-altitude UAS Integration Effort (CLUE) UAS Service Supplier (USS) and other UTM capabilities under development.

Skills Preferred Include: Proficiency in AI/ML algorithm development, protocol analysis, C-sUAS and UTM knowledge, cybersecurity, software/hardware engineering, and an understanding of the Android Tactical Assault Kit (ATAK).

Resilient and Secure Computing on Untrusted Clouds (RESCU Clouds)

The AFRL/RI Resilient & Secure Computing on Untrusted Clouds (RESCU Clouds) program keeps close collaboration ties with highly skilled students, professors, engineers, and researchers from academia and industry to conduct different basic and applied research projects. The peculiar diversity of talents working with and cooperating under RESCU Clouds investigate, design, and implement novel methodologies to securely and efficiently outsource data and distribute computations across heterogeneous hostile computing environments and untrusted Cloud Service Providers (CSPs). The research topics of interest focus on zero trust security and include, but are not limited to, (1) decentralized identity and access control mechanisms and protocols, including those that support anonymity. (2) Novel application of existing cryptographic primitives and protocols to zero-trust computing paradigms. (3) Design cross-cloud, CSP-independent, privacy-aware protocols and frameworks that operate in the presence of emerging zero-trust security mechanisms. (4) Enable secure and transparent migration of application and data across heterogeneous CSPs and facilitate multi-objective optimization in the security-mission trade space. (5) End-to-end data protection, concurrency and consistency for multi-user multi-cloud environments.

Skills Preferred Include: Proficiency in one or more programming languages. Knowledge of one or more of the following topics: Machine Learning (ML), data analytics, cryptography, cloud computing, and blockchain.

Information Systems (RIS)

Multi-Model Knowledge Curation

Human perception relies on a variety of different sensory modalities to interpret and make sense of reality. Ontologies (or knowledge graphs) are one such medium by which to encode reality in such a way that is meaningful to humans and computable for machines. However, current automated approaches

to author and curate ontologies rely primarily on textual modalities and are thus unable to achieve the accuracy of humans that incorporate signals from other forms of input such as vision and sound. Our KnowML research team is interested in work that expands upon existing ontology alignment methods to

incorporate other modalities that may improve the veracity of ontologies and facilitate an evidence-driven knowledge graph that's informed by both humans and automated agents. The knowledge graph will enable the USAF to have a view of reality that is current with our adversaries who continually apply methods of deception on the battlefield. The applications of research include:

- Quality assurance for computer vision image labels that lead to better quality detection models
- New alignments among ontological classes and properties informed by image embedding spaces
- Automatically derived taxonomies that represent highly specialized entities
- Formal understanding for how different representation spaces support different learning tasks

Skills Preferred Include: formal methods, machine learning (transformers, CNNs, etc.), collaborative development (Git, GitLab, etc.), logic systems

Interactive Learning for Mission Planning

Multiple objectives plague Air Force planning software. For example: should a pilot care more about fuel consumption or detection by enemy radar? This depends on the situation. However, currently pilots are given specific orders (such as dropping a bomb in a particular location) and lack user-friendly planning software for completing their missions. This project will focus on making planning software easier to use by teaching it what the most important mission objective is to a particular pilot, allowing the pilot to react to dynamic situations more quickly. The goal of this project will be to find that preference vector more quickly by extending the current method (learning from responses to “is plan A or B better?”). One extension involves exploiting some of the graph structure that the planning software relies upon, and another method involves incorporating the pilot's high-quality feedback (typically of the form "fly here" or "don't fly here"). We might leverage techniques from preference learning and/or multi-armed bandits.

Skills Preferred Include : Strong background in linear algebra and machine learning is required. Some experience with programming and complexity analysis is desirable. Familiarity with terms "active machine learning" and "shortest path problem" would be useful.

Computing and Communications (RIT)

Enhancing Test for Trusted Software

The AFRL/RITA Trusted Software group is composed of computer scientists and engineers that tackle research challenges in the areas of scalable formal methods; model-based engineering and validation; compositional verification techniques for resilience; and automation for abstraction validation, and synthesis. These research topics support security, resilience, and reliability in modern software development processes (Agile, etc). Typical summer topics may include developing theories of quantification and/or calculus of testing, model analysis including traceability to requirements, and software development/programing. State of the art techniques for machine learning and automation are used to pursue solutions for developing and verifying learning-enabled autonomous systems.

Skills Preferred Include: Proficiency in software development languages (C/C++, Java, etc), Mathematics and formal methods background (Theorem Proving, Satisfiability,…), and familiarity with model-based design and related tools (AADL, SysML,…), knowledge of AI/ML principles, Familiarity with linux environments, Version control (GIT, etc)

Assurance of Software Systems

The AFRL/RITA Trusted Software group is composed of computer scientists and engineers that tackle research challenges in the areas of scalable formal methods; model-based engineering and validation; compositional verification techniques for resilience; and automation for abstraction validation, and synthesis. These research topics support security, resilience, and reliability in modern software development processes (Agile, etc). Typical summer topics may include: developing and validating new models and tests for AI-enabled software security vulnerabilities; benchmarking performance and coverage of implemented tests and generation of algorithms and documentation; enable trust by developing formal and static analysis approaches to systematically address of vulnerabilities that might arise in AI-enabled systems across multiple contexts; or examine the Problem-definition context (e.g. modeling, quantifying, and analyzing threats), Solution definition context (secure development, (semi-)formal, static, and dynamic analysis for vulnerabilities), and Requirements context (trust assessment – was the correct system designed and built correctly) to reduce the introduction and/or exploitation of vulnerabilities in modern AI and AI-enabled systems

Skills Preferred Include: Proficiency in software development languages (C/C++, Java, Python etc), mathematics and formal methods background (Theorem Proving, Satisfiability,…), and familiarity with model-based design and related tools (AADL, SysML,…), knowledge of AI/ML principles, Familiarity with Linux environments, Version control (GIT, etc)

Robust Deep Learning and Neuromorphic Hardware for Edge Computing

As a powerful component of future computing systems, deep neural networks (DNNs) are the next generation of artificial intelligence (AI) that explicitly emulate the neural structure and operation of the biological nervous system, representing the integration of neuroscience, computational architecture, circuitry, and algorithms. However, DNNs still have significant architectural limitations: (1) an inefficient processing pipeline for large-scale networks, (2) computationally expensive training methods that cannot keep up with increasing data density, and (3) improper network behavior and decreased accuracy due to anomalous or malicious input data. The scope of this effort is to formulate the fundamental research to advance the understanding of neuroscience, facilitate the development of neuromorphic computing hardware and algorithms, and accelerate neuromorphic computing to an extreme efficiency. Specifically, this research focuses on: (1) building an efficient DNN on embedded development platforms to support edge-enabled applications, (2) improving learning algorithms to discover unknown objects with confidence, and (3) developing a working prototype of neuromorphic hardware with emerging circuitry and/or materials. Additional interest includes exploring robotic applications with respect to multimodal sensory information processed by DNNs and neuromorphic hardware.

Skills Preferred Include: Potential students for algorithm development should have skills in Python and machine learning frameworks (e.g., TensorFlow and/or PyTorch). Students interested in hardware development and demonstration should have skills in microcontroller/FPGA and general familiarity with electronic circuit design.

Advanced Wireless Communications in millimeter-Wave, sub-Terahertz and Terahertz Bands

Today's increasing demand for higher data rates and congestion in conventional RF spectrum have motivated research and development in higher frequency bands such as millimeter-wave, sub-terahertz and terahertzbands. In higher frequency bands such as millimeter wave and terahertz, where channel properties are affected by mobility and atmospheric conditions, an agile system with a flexible, resilient architecture and the ability to adapt to the changing environment is required. AFRL Information Directorate's Wireless Innovations at Spectrum Edge (WISE) laboratory at Innovare Advancement Center (IAC) houses the state-of-the-art testbed to conduct both foundational and applications-focused research in these frequency bends.

For foundational research for wireless communications at spectrum edge, we would like to address the technical challenges in both accessing the spectrum and exploiting the spectrum. We are interested in advanced technologies in architecture, waveform and signal processing that enable access to the emerging spectrum bands that are not traditionally widely used for wireless communications. We are also interested in the radio architecture, system design, waveform, algorithm and protocols that will let us exploit the abundant bandwidth that the spectrum edge for future AF wireless applications. Examples include but are not limited to:

- Novel waveform designs that are robust to the high atmospheric absorption loss.
- Use of novel relay architectures such as reconfigurable intelligent surfaces to solve the blockage problem at higher frequency bands.
- Use of data science tools in machine learning to construct meaningful datasets from few RF data collected at these frequency bands.

We are also interested in applications-focused research that specifically calls for the use of frequency bands at spectrum edge in the proposed applications. Examples include but not limited to high bandwidth links for next-generation mobile communication systems, Air Force and commercial applications that consider converged sensing and communications systems, etc.

Skills Preferred Include: Modeling and simulation of wireless channel. Design and implementation of modern wireless standard waveforms such as IEEE 802.11ad and 3GPP standard waveforms. Laboratory skills such as measurement and data analysis.

Quantum Information Sciences: Quantum Algorithms

The Quantum Information Sciences branch (AFRL/RITQ) performs cutting-edge experimental and theoretical research in a wide range of topics at the frontiers of quantum computing and quantum networking. With a unique interdisciplinary team composed of physicists, engineers, mathematicians, technicians, and computer scientists, RITQ has numerous active research efforts in quantum algorithms and leading quantum technologies such as trapped-ion systems, integrated quantum photonics, and superconducting quantum devices. Below are the application spaces and skillsets desired for four different projects available to choose from broken out by active research efforts.

The Quantum Algorithms team tackles understanding, characterization and exploration of commercially available quantum hardware systems. Application spaces of algorithm development include graph theory optimization and quantum machine learning.

Typical summer projects may include programming on a commercially available quantum hardware platform, quantum simulations, software analysis, and algorithmic development.

Skills Preferred Include: Mathematics or Physics background and familiarity with Python or a Quantum Language

Quantum Information Systems: Trapped Ion Systems

The Quantum Information Sciences branch (AFRL/RITQ) performs cutting-edge experimental and theoretical research in a wide range of topics at the frontiers of quantum computing and quantum networking. With a unique interdisciplinary team composed of physicists, engineers, mathematicians, technicians, and computer scientists, RITQ has numerous active research efforts in quantum algorithms and leading quantum technologies such as trapped-ion systems, integrated quantum photonics, and superconducting quantum devices. Below are the application spaces and skillsets desired for four different projects available to choose from broken out by active research efforts.

The trapped ion team focuses on implementing trapped ion systems using barium 133 and/or ytterbium 171. These isotopes have a combination of properties that make them perform particularly well as a qubit. Past summer projects contributed to the effort at a variety of levels and include a wide range of topics. Examples include: the investigation of a new material for optics mounting, the development of electrical and mechanical ion trap demonstrations, the construction of key pieces of control electronics, and the creation of new versions of existing lab tools at new wavelengths.

Skills Preferred Include: Physics or engineering background. Useful (but not required) skills include experimental design and setup, electronic/circuit design and assembly, mechanical design/CAD, programming (for example Python, MATLAB, or Mathematica).

Quantum Information Sciences: Integrated Quantum Photonics

The Quantum Information Sciences branch (AFRL/RITQ) performs cutting-edge experimental and theoretical research in a wide range of topics at the frontiers of quantum computing and quantum networking. With a unique interdisciplinary team composed of physicists, engineers, mathematicians, technicians, and computer scientists, RITQ has numerous active research efforts in quantum algorithms and leading quantum technologies such as trapped-ion systems, integrated quantum photonics, and superconducting quantum devices. Below are the application spaces and skillsets desired for four different projects available to choose from broken out by active research efforts.

The Integrated Quantum Photonics team centers on both the theoretical and experimental aspects of photon-based qubits. The team develops the technology to generate, manipulate, measure, and quantify entangled photons. Typical summer projects include the production and quantification of entangled photons, programming to automate test equipment, integrated photonic device modeling, and theoretical models for quantum transduction.

Skills Preferred Include: Physics or engineering background, strong mathematics background, and a familiarity with Python and C programming languages. Useful (but not required) skills include experimental design and setup.

Quantum Information Sciences: Superconducting Quantum Devices

The Quantum Information Sciences branch (AFRL/RITQ) performs cutting-edge experimental and theoretical research in a wide range of topics at the frontiers of quantum computing and quantum networking. With a unique interdisciplinary team composed of physicists, engineers, mathematicians, technicians, and computer scientists, RITQ has numerous active research efforts in quantum algorithms and leading quantum technologies such as trapped-ion systems, integrated quantum photonics, and superconducting quantum devices. Below are the application spaces and skillsets desired for four different projects available to choose from broken out by active research efforts.

The superconducting team's research focuses on the investigation of new quantum devices, new qubit control and measurement techniques, and the exploration of fundamental physics relevant to quantum networking architectures, with an emphasis on hybrid superconducting systems – i.e., interfaces between superconducting quantum circuits and other leading quantum modalities, such as trapped-ions and quantum photonic circuitry. Typical summer projects may involve one or more of the following: numerical simulations; programming for data acquisition and data analysis applications; design and assembly of laboratory hardware, including mechanical, electronic, and cryogenic components; and participation in quantum measurements.

Skills Preferred Include: Physics or engineering background; experimental design and setup; mechanical design/CAD; analog and digital circuit design; and Python programming language.