



WARREN B. NELMS INSTITUTE  
FOR THE CONNECTED WORLD

# RESEARCH PORTFOLIO

**UF**  
UNIVERSITY of  
FLORIDA



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## FROM THE DIRECTORS' DESK:

### ABOUT NELMS INSTITUTE RESEARCH

The Warren B. Nelms Institute for the Connected World at the University of Florida was established to lead research and education in all aspects of the intelligent connection of things. Together with our esteemed group of multi-disciplinary faculty members and students, we are developing broad Internet of Things (IoT) technologies and their applications to create more secure, sustainable, and connected communities. With billions of IoT-connected devices already in the world today—and billions more in the coming years—the institute remains at the forefront of this burgeoning field while creating a critical mass of expertise at the convergence of Artificial Intelligence (AI) and IoT.

Our research addresses major world challenges relating to public health, energy, education, transportation, and more. We envision a future where people, things, processes, and data are connected in a more intelligent, more energy efficient, and more secure way.

We invite you to browse our current and ongoing Warren B. Nelms Institute research projects. Many of these projects are collaborative, interdisciplinary, and showcase our unique expertise in IoT and AI.



**Swarup Bhunia, Director**  
ECE Department  
University of Florida



**My T. Thai, Associate Director**  
UFRF Professor & IoT Term Professor  
CISE Department  
University of Florida

# RESEARCH TOPIC AREAS

## IoT TECHNOLOGY

- TA1: Machine Learning/AI
- TA2: IoT Security
- TA3: Smart Systems & Communications

## IoT APPLICATIONS

- TA4: Healthcare
- TA5: Automotive Systems
- TA6: Environment and Agriculture
- TA7: Education & Workforce Development
- TA8: Neuro-engineering
- TA9: Urban and Regional Planning
- TA10: Consumer Electronics
- TA11: Smart Energy

# RESEARCH PROJECTS BY TOPIC

## IOT TECHNOLOGY

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- P1: CDS&E: Machine-Learning-Driven Methods for Multiobjective and Inverse Design of van-der-Waals-Material-Based Devices
- P2: SHF: Small: Enabling New Machine-Learning Usage Scenarios with Software-Defined Hardware for Symbolic Regression
- P3: FAI: Towards a Computational Foundation for Fair Network Learning
- P4: AI Enhanced Side Channel Analysis

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- P5: MeLPUF: A PUF Structures for Low-Overhead IC Authentication
- P6: TREEHOUSE
- P7: Automatic Hardware Trojan Attack Exploration
- P8: Hardware Integrity Verification
- P9: Hybrid FPGA Based PUF
- P10: Verification and Synthesis of Assured Dynamic Cyber Defense with Deception and Counter Deception
- P11: CAREER: Formal Synthesis of Provably Correct Cyber-Physical Defense with Asymmetric Information
- P12: Game-Theoretic Reasoning and Synthesis of Defense with Strategic Deception and Counter-Deception
- P13: CAREER: A Unified Theory of Private Control Systems
- P14: Reactive Swarm Control for Dynamic Environments

## TA2: IoT Security (continued)

- [P15](#): Collaborative Research: SaTC: CORE: Small: SOCIAL: System-on-Chip Information Flow Validation under Asynchronous Events
- [P16](#): Collaborative Research: FMITF: Track 1: DOPaMINE: Distributed Opportunistic Platform for Monitoring In-Situ Networks
- [P17](#): Distributed Opportunistic Monitoring of In-Situ Networks
- [P18](#): Resilient System-on-Chip Architecture
- [P19](#): Post-silicon Validation
- [P20](#): Automatically Validating SoC Firmware through Machine Learning and Concolic Testing
- [P21](#): Collaborative Research: SaTC: EAGER: Trustworthy and Privacy-preserving Federated Learning
- [P22](#): SaTC: CORE: Small: Collaborative: When Adversarial Learning Meets Differential Privacy: Theoretical Foundation and Applications
- [P23](#): Pre-silicon Electromagnetic Side Channel Analysis
- [P24](#): Hardware Accelerator Side Channel Analysis and Mitigation Techniques
- [P25](#): CPS: Medium: Security Certification of Autonomous Cyber-Physical Systems
- [P26](#): SaTC: EDU: Collaborative: Building a Low-cost and State-of-the-art IoT Security Hands-on Laboratory
- [P27](#): CAREER: Towards a Secure and Reliable Internet of Things through Automated Model Extraction and Analysis

## TA3: Smart Systems & Communications

- [P28](#): Autonomous Drone to Drone Charging (D2DC)
- [P29](#): A Miniaturized/Portable NMR
- [P30](#): Strong Memory Based PUF for FPGAs
- [P31](#): Low Cost Device Authentication
- [P32](#): CNS Core: Small: A Hardware/Software Infrastructure for Secured Multi-Tenancy in FPGA-Accelerated Cloud and Datacenters
- [P33](#): Collaborative Research: FET: Small: Massive Scale Computing and Optimization through On-chip Parametric Ising Machines (OPTIMA)
- [P34](#): EAGER: Collaborative Research: Graphene Nanoelectromechanical Oscillators for Extreme Temperature and Harsh Environment Sensing
- [P35](#): FET: Small: Modeling, Simulation, and Design for Robustness and Performance in Semiconductor-Based Quantum Computing
- [P36](#): CAREER: Fast Foveation: Bringing Active Vision into the Camera
- [P37](#): Collaborative Research: SWIFT: LARGE: MAC-on-MAC: A Spectrum Orchestrating Control Plane for Coexisting Wireless Systems
- [P38](#): III: Small: Collaborative Research: Stream-Based Active Mining at Scale: Non-Linear Non-Submodular Maximization
- [P39](#): NeTS: Small: Collaborative Research: Lightweight Adaptive Algorithms for Network Optimization at Scale towards Emerging Services
- [P40](#): Intel SHIP Project
- [P41](#): Collaborative Research: PPOSS: Planning: S3-IoT: Design and Deployment of Scalable, Secure, and Smart Mission-Critical IoT Systems
- [P42](#): Collaborative Research: FMITF: Track I: Property-specific Hardware-oriented Formal Verification Modules for Embedded Systems



# IOT APPLICATIONS

## TA4: Healthcare

- [P43](#): Pasteables: A Flexible and Smart “Stick-and-Peel” Wearable Platform for Fitness & Athletics
- [P44](#): Wearable Ultrasound for Non-invasive Image-guided Neuromodulation
- [P45](#): Knowledge-informed Deep Learning for Apnea Detection with Limited Annotations
- [P46](#): Smart Electropalatography for Linguistic and Medical Applications (SELMA)

## TA5: Automotive Systems

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- [P48](#): CAREER: Integrated Online Coordinated Routing and Decentralized Control for Connected Vehicle Systems
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- [P50](#): Sensor Vulnerabilities of Connected Autonomous Cars
- [P51](#): An Integrative Hands-on Approach to Vehicular Security Education
- [P52](#): REU Site: Secure, Accessible, and Sustainable Transportation
- [P53](#): CNS Core: Small: Collaborative Research: Scalable Penetration Test Generation for Automotive Systems
- [P54](#): Security Assurance for Autonomous Vehicular Communications
- [P55](#): EM Radiation of Modern High-Speed Variable Motor Drive Systems
- [P56](#): Automotive Power Converter EM Radiation Characterization and Suppression

## TA6: Environment and Agriculture

- [P57](#): Light Pollution Monitoring Using A Modular IoT Sensor Platform
- [P58](#): Collaborative Research: OAC CORE: Large-Scale Spatial Machine Learning for 3D Surface Topology in Hydrological Applications
- [P59](#): III: Small: Spatial Deep Learning from Imperfect Volunteered Geographic Information
- [P60](#): Integrating Socio-Economic and Remotely Sensed Information to Characterize Conflict Precursors and Land Degradation Dynamics in Ghana
- [P61](#): NSF: Disentangling cross-scale influences on tree species, traits, and diversity from individual trees to continental scales
- [P62](#): NASA Land Use Land Cover Change Program, South/Southeast Asia Initiative
- [P63](#): NSF Convergence Accelerator Track I: OpenMatFlo: A Platform for Designing, Producing, and Supplying Greener Inks for Additive Construction under Uncertainties

## TA7: Education and Workforce Development

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- [P65](#): Peek Inside the Box: Gamified Learning of Computing Hardware Fundamentals
- [P66](#): Integrating AI Learning into Middle School Science through Natural Language Processing
- [P67](#): Fostering Computer Science and AI Learning through Youth-Led Conversational App Development Experiences
- [P68](#): Engaging High School Students in Computer Science with Co-creative Learning Companions

## TA7: Education and Workforce Development (continued)

- [P69](#): Fostering Collaborative Computer Science Learning with Intelligent Virtual Companions for Upper Elementary Students
- [P70](#): CAREER: Bridging Formal and Everyday Learning through Wearable Technologies: Towards a Connected Learning Paradigm
- [P71](#): Collaborative Research: Innovating Quantum-Inspired Learning for Undergraduates in Research and Engineering
- [P72](#): UF GenCyber Hybrid Program: Rural Ace: Rural High School Students Access to Cybersecurity Education in the Age of AI
- [P73](#): Collaborative Research: Fostering Virtual Learning of Data Science Foundations with Mathematical Logic for Rural High School Students
- [P74](#): A Culturally Relevant Approach to Spatial Computational Thinking Skills and Career Awareness through an Immersive Virtual Environment

## TA8: Neuro-engineering

- [P75](#): Mechanisms, response heterogeneity and dosing from MRI-derived electric field models in tDCS augmented cognitive training: a secondary data analysis of the ACT study
- [P76](#): III: Small: Modeling Multi-Level Connectivity of Brain Dynamics
- [P77](#): Web-based Automated Imaging Differentiation of Parkinsonism
- [P78](#): VCA-DNN: Neuroscience-Inspired Artificial Intelligence for Visual Emotion Recognition
- [P79](#): Collaborative Research: SCH: Trustworthy and Explainable AI for Neurodegenerative Diseases

## TA9: Urban and Regional Planning

- [P80](#): Elements: Cyberinfrastructure Service for IoT-Based Construction Research and Applications
- [P81](#): Collaborative Research: A Dynamic Disruption Prediction System for Transportation Networks at a Road-Segment Level of Granularity
- [P82](#): SCC-PG: SmartCurb: Building Smart Urban Curb Environments

## TA10: Consumer Electronics

- [P83](#): Magnetic Field Emission and Reduction for Magnetic Components
- [P84](#): Collaborative Research: SHF: Small: Towards Variability-Aware Software Analysis and Testing
- [P85](#): NSF Convergence Accelerator Track I: Energy-efficient MetaConductors for Convergence of Sustainable Electronics (E-MC2 of Sustainable Electronics)

## TA11: Smart Energy

- [P86](#): Collaborative Research: CPS: Medium: Adaptive, Human-centric Demand-side Flexibility Coordination At-scale in Electric Power Networks
- [P87](#): Energy Efficiency Improvement for Wireless Power Transfer / charging



# RESEARCH PROJECT DESCRIPTIONS

Underlined Investigators are Warren B. Nelms Institute Faculty Members

## TA1: Machine Learning/AI

### P1: CDS&E: Machine-Learning-Driven Methods for Multiobjective and Inverse Design of van-der-Waals-Material-Based Devices [NSF]

Investigators: Jing Guo

Advanced semiconductor device technologies play a critical role in computing, data storage, artificial intelligence (AI), and quantum technologies. Two-dimensional materials and their heterojunctions form a promising material and structure platform to develop future semiconductor devices. Despite promising technological potentials, their technological adoption has been hindered by several major challenges including predicting device properties accurately and assessing device performance systematically. In this project, computer-aided simulation and design capabilities will be developed to address these challenges by combining AI methods with advanced device simulation. The development of AI-guided computer simulation methods will facilitate fast and accurate prediction of device properties, and enable automatic and efficient design of these nanoscale devices. This project will result in an integrated testbed for research and education on applications of AI methods in nanoelectronics. The project will engage and train high school, undergraduate, and graduate students in the fields of semiconductor and AI technologies. The modeling tools developed in this project will be disseminated as an open-source online resource.

### P2: SHF: Small: Enabling New Machine-Learning Usage Scenarios with Software-Defined Hardware for Symbolic Regression [NSF]

Investigators: Greg Stitt, Ann Ramirez

Despite the widespread success of machine learning, existing techniques have limitations and/or unattractive trade-offs that prohibit important usage scenarios, particularly in embedded and real-time systems. For example, artificial neural nets provide sufficient accuracy for many applications, but can be too computationally expensive for embedded usage and may require large training data sets that are impractical to collect for some applications. Even when executed with cloud computing, neural nets often require graphics-processing unit acceleration, which greatly increases power costs that can already dominate the total cost of ownership in large-scale data centers and supercomputers. Similarly, linear regression is a widely used machine-learning technique, but generally requires model specification or guidance by the user, which is prohibitive for difficult-to-understand phenomena and/or many-dimensional problems. This project shows that symbolic regression complements existing machine-learning techniques by providing attractive Pareto-optimal trade-offs that enable new machine-learning usage scenarios where existing technologies are prohibitive. These symbolic-regression benefits come from three key advantages: 1) automatic model discovery, 2) computational efficiency with minimal loss in capability compared to existing techniques, and 3) lower sensitivity to training set size.

### P3: FAI: Towards a Computational Foundation for Fair Network Learning [NSF]

Investigators: Hanghang Tong, My T. Thai, Ross Maclejewski

Network learning and mining plays a pivotal role across a number of disciplines, such as computer science, physics, social science, management, neural science, civil engineering, and e-commerce. Decades of research in this area has provided a wealth of theories, algorithms and open-source systems to answer who/what types of questions. For example, who is the most influential in a social network? What items shall we recommend to a given user on an e-commerce platform? What Twitter poster is likely to go viral? Who can be grouped into the same online community? What financial transactions between users look suspicious? The state-of-the-art techniques on answering these questions have been widely adopted in various real-world applications, often with a strong empirical performance as well as a solid theoretic foundation. Despite the remarkable progress in network learning, a fundamental question largely remains nascent: how can we make network learning results and process explainable, transparent, and fair? The answer to this question benefits a variety of high-impact network learning based applications in terms of their interpretability, transparency and fairness, including social network analysis, neural science, team science and management, intelligent transportation systems, critical infrastructures, and blockchain networks.

### P4: AI Enhanced Side Channel Analysis

Investigators: Shuo Wang, Yier Jin

Side channel Analysis (SCA) is the process of analyzing unintentional signals caused by running operations in hardware, such as power draw and electromagnetic emanations, for information about the operations being performed. SCA can consistently recover confidential information from algorithms run on microprocessors. Machine, and in particular Deep, Learning greatly expand the threat SCA poses. These techniques allow SCA to be conducted with fewer measurements, and to be successful even when deployed against traditional countermeasures. Transfer learning also allows them to be easily adapted to new targets. Understanding the capabilities of Deep Learning for Side Channel Analysis is an integral step in securing microprocessors and reconfigurable circuits, especially those used in IoT applications, from SCA.

## TA2: IoT Security

### P5: MeLPUF: A PUF Structures for Low-Overhead IC Authentication

Investigators: Swarup Bhunia

Counterfeiting and Piracy of hardware Intellectual Property (IP) is one of the prominent trust issues faced by the semiconductor industries due to the distributed manufacturing model. Physically Unclonable Functions (PUFs) are used for securing electronic devices across the implementation spectrum ranging from Field Programmable Gate Array (FPGA) to system on chips (SoCs). In this work, we modified the previous PUF which is known as Mel-PUF, a fully synthesizable novel PUF structure, and tried to implement this idea on ASIC instead of FPGA .

**P6: TREEHOUSE**

**Investigators:** Swarup Bhunia, Patanjali Sristi

3DIC architectures are a promising solution to the performance and power density issues faced by SoC engineers. Stacking multiple layers vertically or integrating them using intersposer techniques gives chip designers more flexibility to integrate complex functionalities into their designs. However, the distributed supply chain of such architectures only exacerbates the existing trust issues while making it harder to integrate trust assurance techniques used for 2DIC technologies. In this research, we identify the various trust issues in the 3DIC supply chain and also propose mitigation strategies to counter them.

In TREEHOUSE, we present a trust assurance solution to counter piracy, reverse-engineering, and counterfeiting attacks. TREEHOUSE uses scan authentication to detect piracy and counterfeiting, scan-and functional-locking to prevent reverse-engineering. We evaluate the efficiency of our proposed scheme on an example 3DIC design. We show that TREEHOUSE incurs less than 1% area and power overheads while incurring less than 1% increase in overall gate count for each layer.

**P7: Automatic Hardware Trojan Attack Exploration**

**Investigators:** Pravin Gaikwad, Jonathan Cruz, Prabuddha Chakraborty, Swarup Bhunia

The semiconductor industry faces a significant threat from hardware Trojan attacks, which are hidden malicious functionalities. This is due to the current horizontal business model that encourages reliance on untrusted third-party Intellectual Properties (IPs), Computer-Aided-Design (CAD) tools, and design facilities. To counteract these attacks, it is necessary to explore the Trojan attack space quickly and reliably for a given design and have a set of Trojan-inserted benchmarks that meet specific standards. The latter has become essential for the development and evaluation of design/verification solutions to achieve quantifiable assurance against Trojan attacks. While existing static benchmarks provide a baseline for comparing different countermeasures, they only enumerate a limited number of hand-crafted Trojans from the complete Trojan design space. To accomplish these dual objectives, in this work, we present MIMIC, a novel machine learning guided framework for automatic Trojan insertion, which can create a large and targeted population of valid Trojans for a given design by mimicking the properties of a small set of known Trojans. While there exist tools to automatically insert Trojan instances using fixed Trojan templates, they cannot analyze known Trojan attacks for creating new instances that accurately capture the threat model. MIMIC works in two major steps: (1) it analyzes structural and functional features of existing Trojan populations in a multi-dimensional space to train machine learning models and generate a large number of “virtual Trojans” of the given design, (2) next, it binds them into the design by matching their functional/structural properties with suitable nets of the internal logic structure. We have developed a complete tool flow for MIMIC, evaluated the framework, and quantified its effectiveness to demonstrate highly promising results.

**P8: Hardware Integrity Verification**

**Investigators:** Pravin Gaikwad, Jonathan Cruz, Prabuddha Chakraborty, Swarup Bhunia

System-on-chip (SoC) developers increasingly rely on pre-verified hardware intellectual property (IP) blocks acquired from untrusted third-party vendors. These IPs might contain hidden malicious functionalities or hardware Trojans to compromise the security of the fabricated SoCs. Recently, supervised machine learning (ML) techniques have shown promising capability in identifying nets of potential Trojans in third party IPs (3PIPs). However, they bring several major challenges. (continued on next page)

(continued from previous page) First, they do not guide us to an optimal choice of features that reliably covers diverse classes of Trojans. Second, they require multiple Trojan-free/trusted designs to insert known Trojans and generate a trained model. Even if a set of trusted designs are available for training, the suspect IP could be inherently very different from the set of trusted designs, which may negatively impact the verification outcome. Third, these techniques only identify a set of suspect Trojan nets that require manual intervention to understand the potential threat. In this paper, we present VIPR, a systematic machine learning (ML) based trust verification solution for 3PIPs that eliminates the need for trusted designs for training. We present a comprehensive framework, associated algorithms, and a tool flow for obtaining an optimal set of features, training a targeted machine learning model, detecting suspect nets, and identifying Trojan circuitry from the suspect nets. We evaluate the framework on several Trust-Hub Trojan benchmarks and provide a comparative analysis of detection performance across different trained models, selection of features, and post-processing techniques. The proposed post-processing algorithms reduce false positives by up to 92.85%.

**P9: Hybrid FPGA Based PUF**

**Investigators:** Chris Vega, Patanjali SLPSK, Swarup Bhunia

FPGAs are often utilized for testing PUF implementation for ASIC devices. However, there exists a need to develop security primitives tailored for these devices. We investigate the FPGA architecture to develop a PUF which makes full use of the LUT architecture. This takes advantage of the PUF location on the device and the routing constraints to increase the entropy density of the PUF.

**P10: Verification and Synthesis of Assured Dynamic Cyber Defense with Deception and Counter Deception [ARO]**

**Investigators:** Jie Fu

Cyber networks are frequently targeted by resourceful attackers, who identify system vulnerabilities through network reconnaissance and craft customized, multistage attacks. To counter the sophisticated attackers, traditional network security mechanisms (e.g., intrusion detection and firewalls) are often complemented by dynamic defenses including cyber deception and moving target defense (MTD) techniques. Such defenses aim to increase uncertainty and complexity for the attacker by either preventing the attacker from identifying and attacking weak points in the network, increasing the cost of attacks, or distracting the attacker from compromising critical nodes in the network with decoys. However, it is often difficult to assess the effectiveness of such defense mechanisms and to design defense systems with provable performance guarantees. The lack of performance assurance and security guarantees in defense strategies can potentially hinder the use of novel dynamic defense with deception. This project will research and develop formal methods approach and algorithmic game theory for modeling, verifying, and synthesizing provably correct dynamic cyber defense systems with deception and counter-deception. The key goals are: 1) Develop a game-theoretic modeling framework for cyber networks equipped with dynamic defense and deception mechanisms. The modeling framework will enable the development of novel algorithms for verifying and synthesizing proactive defense systems given security specifications in high-level formal logic; 2) Develop game-theoretic synthesis methods for constructing assured active cyber defense strategies with novel deception mechanisms; 3) Develop effective dynamic defense strategies against learning-based attacks in repeated interactions.



**P11: CAREER: Formal Synthesis of Provably Correct Cyber-Physical Defense with Asymmetric Information [NSF]**

**Investigators:** Jie Fu

For mission-critical Cyber-physical systems (CPSs), it is crucial to ensure these systems behave correctly while interacting with open, dynamic, and uncertain environments. Synthesizing CPSs with assurance is a daunting task: On the one hand, the interconnected networks, sensors, and (semi-) autonomous systems introduce unprecedented vulnerabilities to both cyber- and physical spaces; On the other hand, purposeful attacks may aim to compromise more complex system properties beyond traditional stability and safety. For example, in a robotized security patrol system, a successful cyber-attack on the sensor network can be combined with adversarial control commands to compromise the system and disrupt its mission. In this project, the goal is to develop intelligent sensing and control methods for CPSs that leverage advanced cyber defense techniques for constructing provably secured systems subject to high-level complex mission objectives.

**P12: Game-Theoretic Reasoning and Synthesis of Defense with Strategic Deception and Counter-Deception [ARO and DARPA]**

**Investigators:** Jie Fu, Shuo Han

This project is to develop game-theoretic foundations for decision-making in adversarial interactions with asymmetric and imperfect information, with applications to cyber-physical security and defense. It consists of two main research thrusts: (1) Planning and synthesis of deception for defense with asymmetric and imperfect information; (2) Counter deception and cautious reasoning. The technical approach will enable optimal and resilient operations in contested environments under stringent constraints on safety and information security.

**P13: CAREER: A Unified Theory of Private Control Systems [NSF]**

**Investigators:** Matthew Hale

This project will develop new differential privacy mechanisms and novel privacy/performance tradeoffs for several classes of control systems, and it will deploy all of these theoretical developments to sensory data gathered at the UF Innovation Hub, which is a smart building on campus.

**P14: Reactive Swarm Control for Dynamic Environments [ONR]**

**Investigators:** Matthew Hale

This project will develop novel decentralized feedback optimization strategies that use an online optimization algorithm as a controller to maneuver swarms in real time. This methodology will eliminate the need to predict future conditions, which typically cannot be done in unknown and adversarial environments, and its theoretical developments will be complemented by outdoor experiments to validate success.

**P15: Collaborative Research: SaTC: CORE: Small: SOCIAL: System-on-Chip Information Flow Validation under Asynchronous Events [NSF]**

**Investigators:** Sandip Ray

We live in an era where smart, connected computing devices pervade many critical applications, including transportation systems, industrial automation, health and biomedical systems, etc. Naturally, these devices create, process, and exchange significant sensitive information. Unauthorized or malicious access to these assets can result in disastrous consequences, including loss of human life in the case of health monitoring systems. The goal of this project is to create a comprehensive infrastructure for information flow validation, i.e., ensuring that sensitive assets in modern System-on-Chip designs cannot be accessed or corrupted by an unauthorized or untrusted agent. The over-arching goal is to develop a scientific foundation and a comprehensive automated framework of integrated tools for systematically addressing the spectrum of challenges in information flow validation. The research objectives are tightly integrated into teaching and outreach activities, in the form of new curriculum development, organizing security competitions in premier conferences, recruitment of female and underrepresented minority students, and involving high-school graduates in research.

**P16: Collaborative Research: FMitF: Track 1: DOPaMiNe: Distributed Opportunistic Platform for Monitoring In-Situ Networks [NSF]**

**Investigators:** Sandip Ray

Given the importance of emerging wireless networks that utilize dynamic spectrum allocation to the future national economy, it is critical to find protocol shortcomings that can result in failures as well as determine mechanisms for detection and defense against attacks that exploit protocol vulnerabilities either in the protocol specifications or their implementations. This research will develop a distributed opportunistic platform for monitoring deployed wireless networks and formal verification tools that use this data to certify safe and robust protocol operation in the field. Measurements of 4G LTE networks using a software-defined radio (SDR) platform will provide the runtime traces and channel information for new verification algorithms. New tools for rapidly verifying correct protocol operation in a variety of real-world operational scenarios will be developed. The research results will be integrated into next-generation protocol design. Consequently, this work will have a transformative societal impact by dramatically increasing the robustness and security of emergent wireless protocols. A key impact will be early identification of protocol and implementation weaknesses, which will be communicated to industry and standards organizations. All aspects of the framework, including architectures, tools, and case studies, will be made publicly available. Hands-on training modules will be developed to illustrate key concepts of wireless protocols and their security implications, which will be integrated into graduate/undergraduate classes. These courses will provide a key pathway for the dissemination of the research results. Female and minority students will be engaged through interdisciplinary research projects.

**P17: Distributed Opportunistic Monitoring of In-Situ Networks**

**Investigators:** Sandip Ray

Imagine what would happen if all wireless communication stopped suddenly. There would be mass panic since many people have never known any other way of communicating. There would also be catastrophic failure of many systems and processes that have been built on top of a wireless communication system, e.g., autonomous vehicles, navigation systems, and increasingly, smart devices in the home, office, and hospitals. In other words, the consequences of a breakdown of the wireless communications plane are severe. One can argue that this scenario is unlikely because of the standards process by which wireless communication devices and networks are designed. On the other hand, while the standards process produces efficient protocols, rigorous mathematical assurance of their safe and predictable behavior on diverse complex distributed deployment scenarios has been lacking. Consequently, we face the very real possibility of rare) unexpected protocol behaviors which may result in failure or there may exist unknown vulnerabilities that can be exploited by unfriendly third parties. Given the ease of using powerful software-defined radios, the potential for unintentional or intentional malicious behaviors also increases. As we move towards 5G and future networks with dynamic spectrum allocation, the set of potential failure modes multiplies. For instance, unintentional spectrum squatting or intentional attacks that force legitimate users to vacate spectrum or trigger their devices into conservative protocol behaviors that use less bandwidth are possible. This project focuses on addressing this crucial problem. The project will develop a flexible, powerful distributed platform for monitoring deployed networks, and analysis tools that use this data to certify safe and robust protocol operations in field. The research is performed in close collaboration between the University of Florida and Portland State University. The anticipated approach will involve a tight mix of analytic and experimental components. The analytic work will extend existing formal verification methods to certify assurance of trustworthy execution of deployed protocols. The experimental work will utilize traces from deployed networks to demonstrate viability of the analysis. The anticipated result will be powerful assurance infrastructure to certify robustness of wireless communication systems against failures and malicious exploitation, and detect vulnerabilities and non-compliance of system executions in real-time.

**P18: Resilient System-on-Chip Architecture**

**Investigators:** Sandip Ray

System-on-Chip (SoC) design involves composition of pre-designed hardware blocks into a single integrated circuit. SoCs are readily being applied in various domains like healthcare, cyber-physical systems, automotive, etc. A modern SoC design includes a variety of processor cores, memory systems, cryptographic blocks, communication modules (e.g., wireless and LTE modules), debug and peripheral driving interfaces (e.g., JTAG, HDMI, etc.), power management units, and many others. The individual hardware blocks, referred to as intellectual properties (“IP” for short) are procured through a global supply chain of IP vendors. System functionality is implemented through communication of IPs through a variety of system interconnects. SoC designs promise much faster design time, robustness, and configurability than custom hardware. Unsurprisingly, SoC designs have seen explosive proliferation in electronic computing system architectures, particularly as we move into the era of hundreds of billions of devices. A key concern with the proliferation of SoC designs is security. As we move towards Internet-of- Things, these systems are continually tracking, analyzing, and communicating some of our most intimate personal information, including sleep patterns, health, location, etc. In addition to private end-user information, they also sensitive information in modern SoC designs include security-critical parameters introduced during the system design, e.g., fuses, cryptographic and Digital Rights Management (DRM) keys, firmware execution flows, on-chip debug modes, etc. Sensitive information or data in a modern computing system will be collectively referred to as “assets”. (continued on next page)

(continued from previous page) Unauthorized or malicious access to these assets can result in leakage of company trade secrets for device manufacturers or content providers, identity theft for end users, subversion of national security, and destruction of human life. It is vital to our well-being to ensure that these assets in computing devices are protected from unauthorized, malicious access. The goal of this project is to enable a streamlined, disciplined approach for implementing and validating diverse security requirements in modern SoC designs. A key contribution of the project has been the establishment of an architectural framework for implementing a spectrum of security policies, including access control, information flow, time-of-check vs. time-of-use, etc. The framework introduces a centralized policy implementation IP that communicates with the various hardware modules in the SoC design to implement target policies. We demonstrated how the architecture can facilitate implementation of diverse security requirements (even in the presence of untrusted IPs) and streamline their validation. The approach holds the promise to usher in a new “patchable” SoC architecture, i.e., systems developed with hardware that can be reconfigured and updated in field just like we can update software or firmware components.

**P19: Post-silicon Validation**

**Investigators:** Sandip Ray

The size and complexity of a modern electronic computing systems precludes catching all design errors by functional verification (formal or otherwise) only on pre-silicon models. Indeed, an estimated 50% of modern SoC designs contain functional errors in the first fabricated silicon. Consequently, post-silicon verification has become a critical component of the overall verification flow. Post-silicon verification entails running simulation on first-pass fabricated silicon to detect functional bugs which are missed during pre-silicon validation. Since post-silicon execution proceeds at target clock speeds, it permits a much deeper exploration of the design space than afforded by pre-silicon. However, a key challenge in post-silicon verification is limited observability: only a few of the thousands of important internal signals are observable during normal chip operation. Observability is constrained by the number of pins and size of available internal buffers in the design. The situation is exacerbated by the current architectural trend away from a conglomeration of individual chips aggregated within a motherboard towards System-on-Chip (SoC) designs with system functionality within a single silicon substrate: with high integration afforded by the SoC architecture, the number of pins and correspondingly external observability, is getting increasingly diminished. The goal of this project is to streamline and systematize post-silicon validation of hardware systems targeted towards current and emergent applications. We aim to develop a comprehensive TFM (tool, flow, methodology) with (1) effective and scalable algorithms for selection and qualification of post-silicon observability that affords amelioration of the limited observability problem without reduction in validation quality, (2) automation in post-silicon triage and diagnosis, and (3) a formally guaranteed post-silicon coverage. Finally, we are investigating clear and tight connection between pre-silicon and post-silicon validation to facilitate comprehensive assurance of system functionality and performance.



**P20: Automatically Validating SoC Firmware through Machine Learning and Concolic Testing [SRC]**

**Investigators:** Sandip Ray

Recent years have seen a dramatic increase in the size and complexity of firmware in both custom and SoC designs. Unlike custom hardware, a system functionality implemented through firmware can be updated after deployment in response to bugs, performance limitations, or security vulnerabilities discovered in-field, or for the purpose of adapting to changing requirements. Today, it is common to find more than a dozen hardware blocks (also referred to as “intellectual properties” or “IPs”) in a commercial SoC design implementing significant functionality through firmware that execute on diverse microcontrollers with different instruction set architectures, e.g., IA32, ARMTM, 8051, etc., as well as proprietary custom instruction set. Firmware implementations are particularly common for many core algorithms in machine learning systems, since these algorithms typically need to be adapted and updated in-field in response to evolving data patterns, workloads, and use cases throughout the lifetime of the system. Given this extensive use, it is getting increasingly crucial to ensure that the firmware implementations are functionally correct, robust against various microarchitectural side channels, and protected against malicious security exploitation. The goal of this project is to develop an automated framework for dynamic firmware validation that enables exploration of subtle hardware/firmware interactions while maintaining the scalability and performance. Our approach exploits some key insights from formal techniques to achieve scalability in test generation. It involves innovative coordination of two components: (1) a configurable, plug-and-play Virtual Platform (VP) architecture that enables disciplined, on-the-fly selective refinement of hardware modules from VP to RTL; and (2) a concolic test generation framework that combines symbolic analysis with machine learning for targeted exploration of firmware paths that have a high probability of exhibiting errors and vulnerabilities (if they exist). The outcome is a comprehensive, automated methodology for firmware analysis that (1) can be employed early in the system exploration life-cycle, (2) accounts for the interaction of the firmware with the underlying hardware and other IPs, and (3) enables focused, targeted exploration of firmware code to identify functional error conditions and security vulnerabilities.

**P21: Collaborative Research: SaTC: EAGER: Trustworthy and Privacy-preserving Federated Learning [NSF]**

**Investigators:** My T. Thai

Researchers and the public have been alarmed by a fact that user privacy of training data in machine learning (ML) models has been exploited in many ways, leading to a rapidly expanding field of federated learning (FL). In FL, the learning of ML models is performed directly on user devices, while the aggregated model is composed with a help of a central server. As data never leave user devices, this new paradigm offers a key promise to protect data privacy. It, unfortunately, poses new challenges in both security and privacy. On one hand, malicious users can compromise security by injecting backdoors into the model updates, thus poisoning the aggregated model. On the other hand, there is a risk of privacy leakage as an untrusted server can inverse the model update to expose private data. This project develops a principled and systematic FL framework that simultaneously offers both privacy and security protection against threats from malicious users and servers. As part of this project, novel protocols will be developed to ensure verifiability, execution integrity, model confidentiality, and protection against adversarial attacks. The success of the project holds significant potential in expanding machine learning to new application scenarios, especially, when no trust is assumed among the stakeholders. The findings may also benefit other fields, such as zero-knowledge proof, distributed machine learning, and distributed ledger technology.

**P22: SaTC: CORE: Small: Collaborative: When Adversarial Learning Meets Differential Privacy: Theoretical Foundation and Applications [NSF]**

**Investigators:** My T. Thai

The pervasiveness of machine learning exposes new and severe vulnerabilities in software systems, where deployed deep neural networks can be exploited to reveal sensitive information in private training data, and to make the models misclassify. However, existing learning algorithms have not been designed to be simultaneously robust to such privacy and integrity attacks, in both theory and practice. In field trials, such lack of protection and efficacy significantly degrades the performance of machine learning-based systems, and puts sensitive data at high risk, thereby exposing service providers to legal action based on HIPAA/HITECH law and related regulations. This project aims to develop the first framework to advance and seamlessly integrate key techniques, including adversarial learning, privacy preserving, and certified defenses, offering tight and reliable protection against both privacy and integrity attacks, while retaining high model utility in deep neural networks. The system is being developed for scalable, complex, and commonly used machine learning frameworks, providing a fundamental impact to both industry and educational environments.

**P23: Pre-silicon Electromagnetic Side Channel Analysis**

**Investigators:** Shuo Wang, Yier Jin

Side channel Analysis (SCA) is the process of analyzing unintentional signals caused by running operations in hardware, such as power draw and electromagnetic emanations, for information about the operations being performed. To secure designs from the threat of SCA, defenders often need to iterate through several post-silicon implementations of a design, which is expensive in terms of both time and money. It is also possible to simulate the electromagnetic (EM) behavior of a design, but this is prohibitively time consuming for all but the smallest of circuits. To address this, and better secure circuits, particularly those which will be routinely left physically accessible such as in IoT applications, we are exploring ways to predict EM leakage at the HDL and layout level.

**P24: Hardware Accelerator Side Channel Analysis and Mitigation Techniques**

**Investigators:** Shuo Wang, Yier Jin

Side channel Analysis (SCA) is the process of analyzing unintentional signals caused by running operations in hardware, such as power draw and electromagnetic emanations, for information about the operations being performed. SCA can consistently recover confidential information from algorithms run on microprocessors. However, as hardware accelerated computation has become increasingly popular due to advances in reconfigurable computing, encryptions and other sensitive operations are more often being computed through these components. Evaluating the resilience of hardware implementation of common algorithms and creating new methods to protect and secure them from SCA, is therefore of utmost importance. To this end, we have created a highly adaptable framework for collecting side channel measurements from a variety of devices and designs. This framework also performs both traditional and AI-enhanced SCA to evaluate the security of an implementation. Using this information, we can guide efforts to enhance the robustness of a design.

**P25: CPS: Medium: Security Certification of Autonomous Cyber-Physical Systems**

**Investigators:** Shuo Wang, Yier Jin

Automation is being increasingly introduced into every man-made system. The thrust to achieve trustworthy autonomous systems, which can attain goals independently in the presence of significant uncertainties and for long periods of time without any human intervention, has always been enticing. Significant progress has been made in the avenues of both software and hardware for meeting these objectives. However, technological challenges still exist and particularly in terms of decision making under uncertainty. In an autonomous system, uncertainties can arise from the operating environment, adversarial attacks, and from within the system. While a lot of work has been done on ensuring safety of systems under standard sensing errors, much less attention has been given on securing it and its sensors from attacks. As such, autonomous cyber-physical systems (CPS), which rely heavily on sensing units for decision making, remain vulnerable to such attacks. Given the fact that the age of autonomous CPS is upon us and their influence is gradually increasing, it becomes an urgent task to develop effective solutions to ensure the security and trustworthiness of autonomous CPS under adversarial attacks. The researchers of this project provide a comprehensive real-time, resource-aware solution for detection and recovery of autonomous CPS from physical and cyber-attacks. This project also includes effort to educate and prepare the community for the potential cyber and physical threats on autonomous CPS.

**P26: SaTC: EDU: Collaborative: Building a Low-cost and State-of-the-art IoT Security Hands-on Laboratory [NSF]**

**Investigators:** Shuo Wang, Yier Jin

The Internet of Things (IoT) interconnects everything including physical and virtual objects together through communication protocols. IoT has broad applications in digital healthcare, smart cities, transportation, agriculture, logistics and many other domains. The popularity of IoT has raised security and privacy concerns. This project seeks to improve IoT and privacy education through the development of laboratory module materials. This will include the development of an IoT platform with an industrial grade microcontroller (MCU) equipped with a crypto co-processor that is significantly lower-cost than existing platforms. This platform will allow for the development of a full-fledged IoT laboratory with hardware security modules at a cost that will make it affordable for students and institutions. The proposed IoT platform, teaching labs with both hardware and software, case studies and faculty development summer workshop will help improve curricula, student learning, and faculty collaboration and development at the participating institutes and partner intuitions, including Hispanic Serving Institutions and Historically Black Colleges and Universities (HBCUs).

**P27: CAREER: Towards a Secure and Reliable Internet of Things through Automated Model Extraction and Analysis [NSF]**

**Investigators:** Tuba Yavuz

The PI's long-term career goal is to improve reliability and security of systems code through automated formal methods and software engineering. Recent advances in automated program verification and analysis provide a fertile ground for the proposed research. However, the complexity of systems code impedes high-coverage analysis that is required for formal guarantees. Model-driven approaches provide a rigorous methodology for designing provably secure and reliable models. However, due to a formal gap between the models and their implementations, proving preservation of reliability and security properties by the implementations remains to be a challenge. (continued on next page)

(continued from previous page) Recent studies on the insecurity of emerging Internet of Things (IoT) has re-surfaced the critical gap between models and their actual implementations. The anticipated role of IoT in the quality of our daily lives call for effective solutions for this fundamental problem. This project aims to improve security and reliability of IoT through automated extraction of precise behavioral models of the IoT components and their interactions for effective and efficient reasoning about the functional and non-functional system-level properties as these systems evolve.

**TA3: Smart Systems & Communications**

**P28: Autonomous Drone to Drone Charging (D2DC)**

**Investigators:** Archit Jaiswal, Swarup Bhunia

The Unmanned Aerial Vehicle (UAV) technology has proven to be significantly influential in both military and civilian applications. Among the UAVs, multi-rotor (commonly known as drones) and Vertical Takeoff and Landing (VTOL) are gaining more popularity due to several applications such as delivery services, precision agriculture, and many more. Despite having a wide range of use cases, they have several limitations. The flight endurance of a UAV is constrained by the onboard battery capacity. This issue has vastly impeded their adoption in our everyday life. Charging a UAV is a time-consuming and tedious process. The conventional approach of charging a UAV requires it to be grounded while charging at a slow rate. The UAV must halt the flight mission and return to a charging location in most cases for battery replenishment. In the past, researchers have suggested several techniques like battery hot swap and wireless power transfer to recharge the onboard battery without completely disrupting the flight operation, but they are mostly inefficient and unfeasible. In this research, we are presenting a framework that allows the replenishment of a UAV's battery without disrupting the flight operation with the help of another autonomous UAV. This research proposes an innovative approach of utilizing a multi-level battery architecture to reduce the battery recharge time and increase flight endurance. In this research, we also developed a charge scheduling algorithm that allows power sharing between multiple UAVs to increase the overall flight endurance in a way that improves the health of Li-ion batteries.

**P29: A Miniaturized/Portable NMR**

**Investigators:** Swarup Bhunia

The typical NMR instrumentation is bulky, heavy, and expensive. It is a known fact that improving signal-to-noise ratio involves the use of a high magnetic field. Thus, it introduces the use of a heavy magnet system, a long procurement/setup time, and advanced hardware and transceivers. This has limited the use of NMR to privileged groups like hospitals, advanced labs, and industries. However, NMR is still useful even with the use of a low magnetic field, which enables the development of portable systems with the miniaturized magnet size. Its applications are broad, mainly due to its portability, including analysis of a living sample like a stem tree, food analysis, agricultural product analysis, oil and gas exploration, biological imaging, etc. This project assesses the different aspects of NMR instrumentation hardware in order to make a portable NMR system. It includes the development of a battery-powered high-bandwidth power amplifier, the implementation of high-bandwidth tuned receiver system with modern ICs, and the use of modern SoC-FPGA technology to enable a low-level timing-sensitive NMR pulse programming and a high-level signal processing inside one IC package. Several experimental results are provided showing the capability of the hardware, including T1/T2 analysis of liquid and semi-solid samples, diffusion analysis, and 2D imaging of phantom and biological samples.



**P30: Strong Memory Based PUF for FPGAs**

**Investigators:** Chris Vega, Patanjali SLPSK, Swarup Bhunia

Memory based PUFs are popular in industry use as they offer stable low-overhead responses and are typically immune to machine learning attacks. However, due to their nature of using memory cells they have the drawback of only offering a fixed response. We propose a hybrid memory strong PUF that offers the benefits of a memory a strong PUF. Our proposed solution creates a memory PUF with reconfigurable paths that allow for multiple signatures to be generated while minimizing the area utilized.

**P31: Low Cost Device Authentication**

**Investigators:** Chris Vega, Swarup Bhunia

Device authentication can often be costly, requiring large amounts of data to store keys from enrolled devices. We propose a low-cost authentication scheme that can validate the authenticity of a devices manufacturer and device family.

**P32: CNS Core: Small: A Hardware/Software Infrastructure for Secured Multi-Tenancy in FPGA-Accelerated Cloud and Datacenters**

**Investigators:** Christophe Bobda

The goal of this project is the secure sharing of FPGA resources in multi-tenancy cloud that incorporate FPGAs for hardware acceleration. The research focuses on three subproblems to enable a transparent utilization by cloud tenants: virtualization, FPGA resource management and domain separation. Virtualization is addressed through a combination of paravirtualization, hardware acceleration and dynamic network on chip infrastructure on the FPGA for unrestricted placement of IP tasks at run-time. FPGA resource management is tackled by integrating the spatial and temporal placement paradigm in the cloud management framework. Effort is placed on the design of temporal placement strategies to better allocate accelerators on one or multiple FPGAs at run-time. Isolation is achieved using the FLASK architecture and ensuring that IP inherits security domain policies of the VMs to which they belong. Project result will be validated using a 20-nodes FPGA-accelerated cloud designed and deployed at the University of Florida.

**P33: Collaborative Research: FET: Small: Massive Scale Computing and Optimization through On-chip ParameTric Ising MACHines (OPTIMA) [NSF]**

**Investigators:** Philip Feng

For decades, academia and industry have relied on deterministic algorithms and on general-purpose von-Neumann computing architectures to solve combinatorial-optimization (CO) problems within natural and social sciences. As Moore’s law continues to slow down, the existing computing paradigm is reaching the limit of maximum complexity of the CO problems it can tackle, thus becoming increasingly inadequate to answer, in reasonable times, the fundamental questions that keep rising in a wide range of disciplines, spanning from engineering, physics and medicine to economics and finance. By emulating quantum systems, new computing architectures known as Ising Machines (IMs) have been emerging. (continued on next page)

(continued from previous page) IMs offer the unique opportunity to solve extraordinarily complex CO problems much faster than any existing von-Neumann counterparts. Yet, to date, no IM technology can afford a massive number of spins to handle the currently unsolvable CO problems, while ensuring a low-power consumption, a compact form factor, a chip-scale integration and a manufacturability en masse through the consolidated wafer-scale fabrication processes offered by the semiconductor industry. The goal of this project is to explore and develop a new IM, namely the first On-chip ParameTric Ising MACHine (OPTIMA). Thanks to its unique highly reprogrammable dynamics, triggered without requiring any special environmental conditions or any time-consuming pre-processing steps while exclusively requiring chip-scale components that can be monolithic integrated in favor of a massive scale production, the development of OPTIMA will pave the way towards powerful, fast and miniaturized quantum-inspired computing systems, accessible to everybody from everywhere. This will allow the creation of new cyber infrastructures that scholars, scientists, engineers and educators worldwide will be able to use in order to address relevant technological and social challenges. The project team is collaborating with STEM education and workforce development programs, at both North-eastern University and the University of Florida, to organize and host on-campus activities with students and teachers from both K-12 schools and community colleges, as well as outreach visits to local schools to encourage and broaden participation of underrepresented groups. The project achievements are enriching both the undergraduate and the graduate courses that the investigators teach on circuit theory, advanced acoustic-based technologies for communication and sensing, micro/nanoelectromechanical systems (MEMS/ NEMS), and quantum engineering devices and systems.

**P34: EAGER: Collaborative Research: Graphene Nanoelectromechanical Oscillators for Extreme Temperature and Harsh Environment Sensing [NSF]**

**Investigators:** Philip Feng

Sensors capable of operating at high temperatures with high precision and stability are of great interest and importance for emerging harsh and extreme environments, including but not limited to wildfire, aerospace, engine, nuclear plant, and other critical applications. Today’s mainstream state-of-the-art high-temperature sensing solutions involve multiple components distributed in distant zones at various temperatures and connected via high-temperature cables or fibers, resulting in bulky and ineffective sensing systems. Miniature high-temperature sensors are thus highly desirable, to provide real-time sensing and monitoring capabilities in small form factor, particularly toward future internet of things (IoT) adaptable to harsh environments. To date, integrated high-temperature (up to 1000°C) sensors remain challenging due to the lack of device technologies in both sensing elements and interfacing circuits. In addition to developing a suitable platform, fundamental studies of the effects of ~1000°C high temperature upon devices are greatly needed. This project is focused on innovating 1000°C-capable sensors based on integrating graphene nanoelectromechanical resonators and graphene electronics, by exploiting the inherent high-temperature durability and unique combination of the electrical, thermal, and mechanical properties of graphene. This research will lay the foundation for developing ultracompact, ultralow-weight sensors that can operate at very high temperatures and in harsh environments, especially in energy and aerospace industry, and for environment and disaster monitoring (e.g., to assist drones for fighting wildfires). Findings in this research of atomically thin crystals and their devices will generate fascinating experiential learning materials and inspirations for students from K-12 through graduate school. The project also creates opportunities for broadening the participation of underrepresented and economically disadvantaged groups, and for partnership to bridge the gap between academia and industry in scaled manufacturing.

**P35: FET: Small: Modeling, Simulation, and Design for Robustness and Performance in Semiconductor-Based Quantum Computing [NSF]**

**Investigators:** Jing Guo

Quantum computing has the potential to eventually revolutionize computing technologies and impact many research fields as well as daily life, including discovery of new materials, design of new drugs, financial modeling, security and cryptography, and artificial intelligence. Among various approaches for hardware realization of quantum computing, semiconductor-based quantum computing has the advantage to harvest and leverage the vast infrastructure and success of the semiconductor chip industry, which promises low cost and small size. Significant challenges, however, remain to controllably and precisely entangle semiconductor spin quantum bits (qubits), transmit quantum information between them, and eventually realize a large-scale semiconductor quantum computer. In this project, new simulation methods and computer-aided design (CAD) frameworks will be developed to address key hardware design challenges in semiconductor-based quantum computing. Simulation and design tools will be developed and disseminated online to extensively support the education and research activities in semiconductor quantum computing. By developing new curriculum and engaging students from high school to graduate levels, the project also contributes to addressing the challenge of educating a new generation of quantum workforce.

**P36: CAREER: Fast Foveation: Bringing Active Vision into the Camera [NSF]**

**Investigators:** Sanjeev Koppal

Most cameras today indiscriminately photograph their entire visual field. In contrast, animal eyes have fast mechanical movements that control how the scene is imaged in detail by the fovea, where visual acuity is highest. In computer vision, this idea of actively selecting where to look -- i.e. active vision -- has been mostly demonstrated with slow, power-hungry mechanical options for changing camera pose, such as pan-tilt-zoom motors or robot motion. The key challenge to conducting active vision for small mobile platforms is to provide fast, camera control of the physical properties that influence image formation, such as wavelength, resolution, polarization, viewpoint, exposure time, etc. This project focuses on active vision algorithms for fast adaptive resolution, generalizing the foveation capability found in animals. I propose new designs called \*foveating cameras\*, which work by capturing reflections off a tiny, fast mirror whose scan path allows for selective scene viewing. Foveating cameras will revolutionize sensing in mobile systems and robotics, since algorithms such as visual state estimation or object recognition can now use imagery with high resolution on every region of interest, even if these are at different depths and viewing directions.

**P37: Collaborative Research: SWIFT: LARGE: MAC-on-MAC: A Spectrum Orchestrating Control Plane for Coexisting Wireless Systems**

**Investigators:** Janise McNair, YK Yoon, Soumyajit Mandal

Radio spectrum, which has long been identified as a scarce resource, will be more crowded and diversified than ever, because existing and future wireless systems are destined to operate in an coexisting wireless environment. To keep up with the ever-increasing demand for scarce wireless capacity, pervasive sharing of radio spectrum over a wide range has become the norm, fueled by dynamic spectrum access and cognitive radio technology. (continued on next page)

(continued from previous page) Swift and effective spectrum sharing requires enhanced capability and increased intelligence at the wireless devices, from innovative transmitter and receiver technologies at the physical layer, to multiband spectrum sensing across physical and MAC layer; from mapping spectrum slices for each access request, to radical modification on medium access control (MAC) protocol. Altogether, the objective is to support a myriad of heterogeneous devices that run diverse communication standards over different frequency bands, achieving efficient spectrum and energy utilization in such huge, dynamic and disparate systems, which still remains a daunting task, calling for a synergistic effort across disciplines for maximal benefits of spectrum sharing.

**P38: III: Small: Collaborative Research: Stream-Based Active Mining at Scale: Non-Linear Non-Submodular Maximization [NSF]**

**Investigators:** My T. Thai

The past decades have witnessed enormous transformations of intelligent data analysis in the realm of datasets at an unprecedented scale. Analysis of big data is computationally demanding, resource hungry, and much more complex. With recent emerging applications, most of the studied objective functions have been shown to be non-submodular or non-linear. Additionally, with the presence of dynamics in billion-scale datasets, such as items are arriving in an online fashion, scalable and stream-based adaptive algorithms which can quickly update solutions instead of recalculating from scratch must be investigated. All of the aforementioned issues call for a scalable and stream-based active mining techniques to cope with enormous applications of non-submodular maximization in the era of big data. With the society's growing dependence on the cyberspace and computer technologies, the premium placed on the intelligent big data analysis for many emerging applications. Therefore, the success of this project has a high impact in almost any field that needs lightweight and near-optimal big data analysis. The findings of this project will also enrich the research on network science, graph theory, optimization, and big data analysis. In addition to creating new courses, undergrad and high school students will be involved in hands-on activities over the experimental platform. Outreach events targeted at under-represented groups and K-1.

**P39: NeTS: Small: Collaborative Research: Lightweight Adaptive Algorithms for Network Optimization at Scale towards Emerging Services [NSF]**

**Investigators:** My T. Thai

The past decade has witnessed enormous transformations of information technologies. The era of cloud computing transformed how information is delivered. With more and more devices becoming "smarter" and "plugged" into the Internet (through embedded microprocessors and communication chipsets), we are entering into a new era of "Internet of Things" (IoT) and cyber-physical systems where the cyber world and physical world are increasingly integrated through a variety of sensors and actuators that are planted into the physical world but controlled through the cyber world. Both today's cloud services and emerging IoT applications alter the point-to-point communication paradigm of the existing IP Internet architecture, and require increasingly demanding quality-of-service (QoS) requirements. These requirements call for scalable and intelligent network algorithms for controlling and coordinating various network components and managing and optimizing resource allocations, with capabilities 1) to meet ever stringent availability, reliability and QoS requirements demanded by emerging services; 2) to cope with the enormous complexity of networked systems; 3) to effectively exploit the rich diversity and redundancy inherent in such complex systems as well as the new capabilities offered by new networking architectures and technologies.



**P40: Intel SHIP Project**

**Investigators:** Shuo Wang, Yier Jin

Transforming gate-level circuit designs into hypergraphs allow for more efficient analysis and sub-division. Specifically partitioning hypergraphs into several small subgraph reduces workload when inserting configurable LUTs and programmable switchboxes and interconnects in the design. This allows traditional Designs to be more readily implemented in FPGAs and other reconfigurable logic devices, and potentially reduces overheads when doing so. Reducing overheads is especially pertinent when developing solutions for IoT applications.

**P41: Collaborative Research: PPOSS: Planning: S3-IoT: Design and Deployment of Scalable, Secure, and Smart Mission-Critical IoT Systems**

**Investigators:** Shuo Wang, Yier Jin

The growing capabilities of sensing, computing and communication devices are leading to an explosion of Internet of Things (IoT) infrastructures. In the meantime, advances in technologies such as autonomous systems and artificial intelligence promise enormous economic and societal benefits. Naturally, it is desirable to deploy these technologies in IoT infrastructures. However, such deployments present daunting changes for increasingly scaled-up IoT infrastructures in mission-critical applications such as medical, energy, transportation, and industrial-automation systems. These challenges stem from several major aspects in terms of scalability. First, the number of edge devices can be enormous, often in the order of billions, which makes centralized management infeasible. Second, there are multiple layers of heterogeneity. An IoT system can consist of heterogeneous computing subsystems; each subsystem can have heterogeneous computing devices; and each single device can be composed of different kinds of computing components. Third, mission-critical applications have stringent requirements in correctness, resilience, timeliness, security and safety. It is difficult for a large-scale IoT system to satisfy these requirements due to increasing opportunities for adversarial activity.

**P42: Collaborative Research: FMitF: Track I: Property-specific Hardware-oriented Formal Verification Modules for Embedded Systems [NSF]**

**Investigators:** Tuba Yavuz, Shuo Wang, Yier Jin

Developing reliable and secure systems requires a deep understanding of the full software stack and the hardware architecture. Complexity of software and the hardware makes it very challenging to construct a comprehensive view of computing systems, which leads to overly optimistic assumptions about the software or the hardware. Despite recent advances in the decision procedures and the analysis techniques, hardware software co-verification is challenged by the scalability issue. Although run-time verification can be used potentially to overcome the scalability challenge, for embedded systems the success of runtime verification highly depends on the proper configuration. We propose a property-directed run-time verification approach that utilizes hardware software co-model extraction for improved bug detection capability, overhead, and precision.

**TA4: Healthcare**

**P43: Pasteables: A Flexible and Smart “Stick-and-Peel” Wearable Platform for Fitness & Athletics**

**Investigators:** Reiner Dizon-Paradis, Prabuddha Chakraborty, Rohan Reddy Kalavakonda, Swarup Bhunia

Wearable technologies, such as smartwatches and health monitoring bands, are becoming increasingly popular and transforming our fitness and sports industry. Monitoring health parameters and body activity can help achieve fitness goals, improve sports performance, and aid in physiotherapy. However, state-of-the-art wearable devices are often not flexible (i.e., targeted to a specific use case), expensive, hard to set up, or have privacy concerns. They are designed and optimized for a specific application with tight hardware-software integration, and it is hard or impossible to re-purpose them for diverse use cases. In this paper, we propose a flexible, reconfigurable human body movement and health monitoring platform, called “Pasteables”. It is a stick-and-peel device (which acts like a band-aid) that attaches to the skin or clothing and can create an on-body network of smart wearables. Given an application, Pasteables can be easily adapted to its requirements while ensuring good performance and privacy. We present the overall architecture, system design steps, and the configuration process. We have designed a set of functional prototypes and configured them for performing a variety of camera-less pose and posture detection tasks, which are important for athletes, professional dancing, physiotherapy, and fitness workouts. We note that the Pasteables can perform pose/posture detection without external stationary reference at low cost and high accuracy.

**P44: Wearable Ultrasound for Non-invasive Image-guided Neuromodulation [NIH]**

**Investigators:** Junjun Huan, Swarup Bhunia

Low-intensity focused ultrasound (FUS) is an emerging non-invasive and spatially/temporally precise method for modulating the firing rates and patterns of peripheral nerves. We are developing an image-guided wearable platform for chronic and patient-specific FUS neuromodulation. The platform uses functional feedback based on detecting muscle activation for real-time optimization of the acoustic energy delivered to the targeted nerve. The system uses custom body-conformal probes that contain separate ultrasound imaging and modulation arrays using piezoelectric transducers. The imaging array generates high quality B-mode images on both straight and curved surfaces that are analyzed using a template-matching algorithm or deep learning model to localize the target nerve and then direct the modulation beam towards the target. A portable FPGA-based Ultrasound scanning system will also be built and integrated with the platform to achieve point-of-care applications.

**P45: Knowledge-informed Deep Learning for Apnea Detection with Limited Annotations**

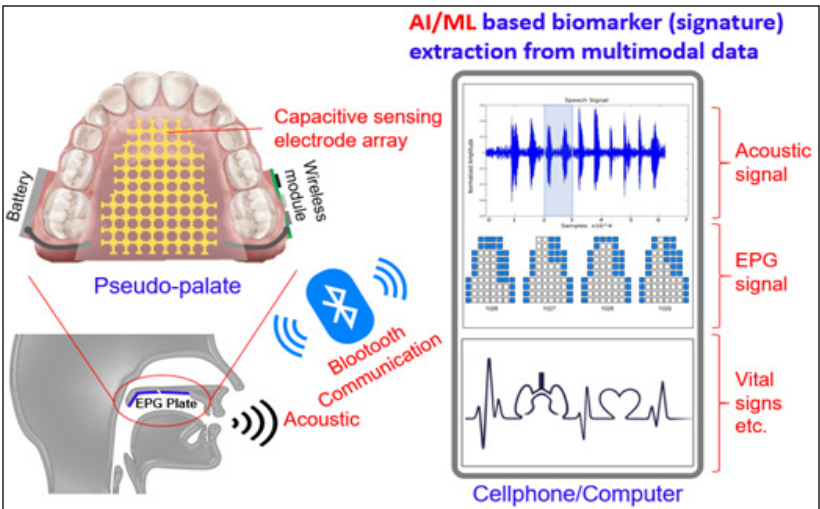
**Investigators:** Xiaochen Xian, Richard Berry

This project aims at developing domain knowledge-informed weakly supervised learning framework for the purpose of enabling automated learning with limited data availability for comprehensive sleep profile learning and monitoring. The study is expected to establish new deep learning models that incorporate noisy, limited, or imprecise coarse-grained annotations and clinical knowledge for analyzing sleep data with higher accuracy, which has the potential to be scaled to large populations with low cost and to catalyze new findings on sleep studies.

**P46: Smart Electropalatography for Linguistic and Medical Applications (SELMA)**

**Investigators:** YK Yoon, Ratree Wayland, Kevin Tang, Lori Altmann

A micromachined smart pseudopalate system equipped with an electrode sensor array and wireless module is proposed for the linguistic and brain function disorder such as Parkinson’s disease. The system is incorporated with AI/ML algorithm to analyze the detected signals. It is a minimally invasive system and will have huge impacts on both linguistic applications such as lenition study, accent reduction, and medical applications such as Alzheimer disease, concussion etc.



Concept of Smart Electropalatography for Linguistic and Medical Applications (SELMA)

**TA5: Automotive Systems**

**P47: A (near) Real-time Framework For Smart Integration of Electric Vehicles to Microgrids [NSF]**

**Investigators:** Zoleikha Biron

The growth of electric vehicle (EV) adoption creates a timely opportunity for utilities and power systems to boost revenue and build sustainable load growth. However, uncontrolled EV to power grid integration, particularly in smaller-scale power systems such as microgrids, brings significant problems, e.g., power flow fluctuation and unacceptable load peaks reducing power network reliability and power quality. In this project we develop a framework to use the flexible energy capacity of EVs to provide services for microgrids. This method increases EV owners’ engagements and will enhance social welfare for all shareholders of the vehicle to microgrid (V2M) connection including EV owners, intelligent charging stations (ICs), and microgrids. Considering the vast amount of data required for managing a large number of EVs in a microgrid, the project will employ advanced machine learning techniques and analytical approaches to reduce the computational complexity of the problem. The proposed framework will provide an understanding of the characteristics and requirements for future cyberinfrastructure design, particularly in integrated large-scale ecosystems. This work represents a broad, novel contribution to literature, education, outreach, and diversity; as such, the project aligns with NSF’s mission to promote the progress of science and to advance prosperity and welfare.

**P48: CAREER: Integrated Online Coordinated Routing and Decentralized Control for Connected Vehicle Systems [NSF]**

**Investigators:** Lili Du

Traffic congestion jeopardizes the function of urban transportation systems and has a growing negative effect on the health of urban economies. It also increases air pollution with numerous negative health impacts on our citizenry. A promising solution to alleviating traffic congestion is to establish coordinated driving mechanisms. This is enabled by recent connected or even autonomous vehicle technologies and advanced onboard computing facilities. However, engineers who design such mechanisms are still lacking scientific knowledge and effective tools that can be proven as efficient and reliable for use by the general public. The goal of this Faculty Early Career Development (CAREER) program award is to develop innovative approaches to the coordination of connected vehicle drivers- online route choices. This will be done by exploiting emerging information and computing technologies equipped in connected transportation infrastructure. This approach will improve transportation system mobility, safety, and environmental sustainability without sacrificing the interests of the individual vehicles. This research will deepen our understanding of the competition among vehicles on limited traffic resources. It should also reveal the impacts of the decisions of individual vehicles on traffic congestion, and offer a new paradigm of real-time traffic control.



**P49: Smart Vehicle Platooning Built upon Real-Time Learning and Distributed Optimization**

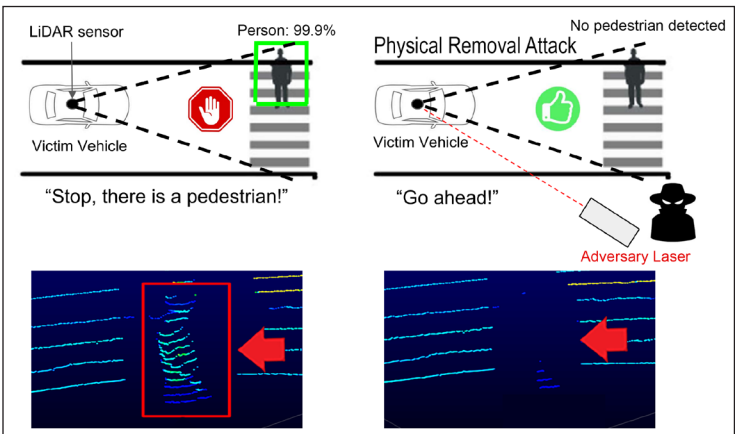
**Investigators:** Lili Du

Emerging connected and autonomous vehicle (CAV) technologies offer great potentials to reduce traffic congestion and improve traffic efficiency. However, much of the CA related work focuses on individual vehicles’ safety, which compromises traffic efficiency when mixed traffic (CAVs and human-driven vehicles) is on the road interacting with each other. This project aims to study how a group of CAVs can respond to exogenous disturbances resulting from human-driven vehicles, lane change requests and abnormal traffic and cyber conditions through cooperative speed or acceleration control. The research will improve road safety and traffic efficiency of future transportation systems involving CAVs. This project will disseminate research and education outcomes to broader audiences, including under-represented college and K-12 students with a particular focus on minority students. The specific research objectives of this project are to develop vehicle platoon centered optimal, adaptive, and resilient vehicle platooning control under various normal or abnormal traffic and/or cyber conditions. This project will develop (a) advanced model predictive control integrating distributed optimization for optimal vehicle platooning control under normal traffic/cyber conditions; (b) mixed integer programming based model predictive control for optimal vehicle platooning control adaptive to lane change requests; (c) resilient vehicle platooning control integrating real-time learning and distributed optimization under abnormal traffic and/or cyber conditions.

**P50: Sensor Vulnerabilities of Connected Autonomous Cars**

**Investigators:** Sara Rampazzi

Connected Autonomous Vehicles (CAVs) are able to interact with each other and the environment, and, just like humans, have the ability to make their own decisions without supervision. These systems perceive, learn, and predict their surroundings thanks to sensors and advanced machine learning-based algorithms that detect obstacles, track other vehicles, and perform automated driving operations. However, despite the progress achieved in this technology, autonomous cars are becoming a constant target of cyberattacks. In particular, novel attacks on sensors can manipulate autonomous cars into seeing non-existent obstacles, ignoring real ones, or inducing the vehicle to perform dangerous maneuvers. The research project in collaboration with Toyota InfoTech Lab consists of systematically exploring hardware attacks on autonomous driving and addressing emerging threats with the use of hardware and software techniques combined.



A potential cyberattack on a connected autonomous vehicle.

**P51: An Integrative Hands-on Approach to Vehicular Security Education [NSF]**

**Investigators:** Sandip Ray, Janise McNair, Swarup Bhunia, Wanli Xing

Automotive systems have rapidly transformed in recent years, with an explosive infusion of autonomous features. These features integrate a variety of new sensors, actuators, computer elements, communication protocols, and software. Unfortunately, this trend also has increased the vulnerability of these systems to cyber-attacks. There has been limited awareness of the cybersecurity challenges posed by automotive electronics, even within the cybersecurity research community. This project will address this crucial problem by developing an exploration platform and suite of experiments to enable the dissemination of vehicular security concepts. The platform will target multidisciplinary undergraduate students across STEM areas relevant to transportation. It can be deployed as a comprehensive hands-on lab in a course targeting vehicular security. Individual experiments can also be used in a cybersecurity, hardware security, or wireless networking course, on the one hand, and courses on vehicular systems traditionally offered in Civil and Mechanical Engineering departments on the other. Modules from the platform can also be used for training transportation engineers, vehicular electronics designers, and practitioners in the security of hardware and cyber-physical systems.

**P52: REU Site: Secure, Accessible, and Sustainable Transportation [NSF]**

**Investigators:** Sandip Ray, Wanli Xing

The University of Florida will conduct a REU site to host a diverse cohort of students who will (1) engage in high-impact research on emergent autonomous and sustainable transportation systems with engineering faculty and graduate student mentors, (2) get trained in foundational research skills through hands-on projects, workshops and trainings, and (3) disseminate research results through oral and written communication. As we move towards autonomous transportation, it is critical to explore and comprehend the needs and trade-offs among security, sustainability, and accessibility to improve human lives and benefit society. The site will specifically target engaging students from minority serving institutions and universities with limited research opportunities that contribute to the diversity of the future workforce. A unique feature for the site is the emphasis on cross-disciplinary collaboration for research activities. Students will get the opportunity to work on problems spanning Computer Science, Electrical Engineering, Mechanical Engineering, and Civil Engineering, jointly mentored by faculty members from different engineering disciplines with a history of collaboration on transportation problems.

**P53: CNS Core: Small: Collaborative Research: Scalable Penetration Test Generation for Automotive Systems [NSF]**

**Investigators:** Sandip Ray

This project develops a comprehensive framework for security validation of modern automotive systems. With increasing autonomy, automotive systems are evolving into very complex distributed systems. They contain more than a hundred electronic control units (ECU), a heterogeneous collection of sensors and actuators, several in-vehicle communication networks, and several hundred megabytes of software. Currently security validation of these systems depends primarily on human expertise to identify vulnerabilities in design and implementation. Clearly this does not scale to large complex systems. The project addresses this problem by introducing automated penetration testing methods capable of handling the exploding automotive system complexities.





**P58: Collaborative Research: OAC CORE: Large-Scale Spatial Machine Learning for 3D Surface Topology in Hydrological Applications [NSF]**

**Investigators:** Zhe Jiang

Rapid advances in sensing technology and computer simulation have generated vast amounts of 3D surface data in various scientific domains, from high-resolution geographic terrains to electrostatic surfaces of proteins. Analyzing such emerging 3D surface big data provides scientists an opportunity to study problems that were not possible before, such as mapping detailed surface water flow and distribution for the entire continental US. Despite its vast transformative potential, machine learning tools to analyze large volumes of 3D surface data are not readily available. The project aims to fill this gap by designing a novel parallel spatial machine learning framework for 3D surface topology and implementing the system in a distributed computing environment. The system can produce high-quality observation-based flood inundation maps derived from satellite images. In collaboration with federal agencies (e.g., U.S. Geological Survey, NOAA), the project will enhance situational awareness for flood disaster response and improve flood forecasting capabilities of the NOAA National Water Model by filling in the gap of lacking observations in model calibration and validation.

**P59: III: Small: Spatial Deep Learning from Imperfect Volunteered Geographic Information [NSF]**

**Investigators:** Zhe Jiang

This project aims to investigate novel spatial machine learning algorithms based on imperfect volunteered geographical information as ground truth for applications at the intersection of machine learning and geographic information science. The rapid growth of geospatial and spatiotemporal data being collected from space, airborne, and terrestrial platforms provides scientists, farmers, and first responders critical information they need about the surface of the Earth. This emerging area that intersects machine learning, especially deep learning, with geographic information science is called GeoAI. GeoAI can potentially transform society by addressing grand challenges such as rapid disaster response, water resource management, and transportation. One major obstacle, however, is that deep learning heavily relies on a large number of training labels, which are often not easily available for geographic applications due to slow and expensive field surveys. Existing research on semi-supervised learning could not fully resolve the issues due to the complex nature of geographic data such as spatial heterogeneity. This project will fill the gap by exploiting large scale, low-cost, and near real-time volunteered geographic information. The project will contribute towards the next generation water resource management for the U.S. in the 21st century. This research can not only improve the situational awareness for disaster response agencies but also enhance the flood forecasting capabilities of the National Water Model.

**P60: Integrating Socio-Economic and Remotely Sensed Information to Characterize Conflict Precursors and Land Degradation Dynamics in Ghana**

**Investigators:** Aditya Singh, Jasmeet Judge, Changjie Chen, Olivier Walther, Gregory Kiker

This project builds on a series of mapping tools developed by the Ghana Land Use Project (GALUP) at the University of Florida since 2020. Using cutting-edge technologies, it will develop a web-based application that allows stakeholders to assess land use conflict in their region and contribute to better inform spatial planning policies in Ghana. This project will be using remote sensing to develop a land use conflict identification and land degradation framework. It will combine images collected by drones and satellites with high-resolution socioeconomic data to monitor land degradation and deforestation in the country and monitor risks of artisanal mining and charcoal production in Ghana.

**P61: NSF: Disentangling cross-scale influences on tree species, traits, and diversity from individual trees to continental scales [NSF]**

**Investigators:** Ethan White, Stephanie Bohlman, Daisy Wang, Alina Zare, Aditya Singh

Develops AI-based techniques to utilize airborne hyperspectral and hyperspatial imagery to investigate environmental controls on tree species structure and distributions across the continental United States.

**P62: NASA Land Use Land Cover Change Program, South/Southeast Asia Initiative**

**Investigators:** David Skole, Aditya Singh, Ruth DeFries, Forrest Fleishmann, Randy Wynn, Joshua Gray

South Asian smallholder forests and other tree-based systems: synthesizing LCLUC data and approaches to foster a natural climate solution that improves livelihoods.

**P63: NSF Convergence Accelerator Track I: OpenMatFlo: A Platform for Designing, Producing, and Supplying Greener Inks for Additive Construction under Uncertainties [NSF]**

**Investigators:** Chaofeng Wang, Robert Ries, My T. Thai, Xinyue Ye, Hongyu Zhou

This convergence accelerator project is intended to address the issue of carbon dioxide (CO2) emission of the construction industry, where the concrete sector is a top source of global CO2 emissions. The burgeoning technology of additive construction, or three-dimensional construction printing (3DCP), might exacerbate the situation. Because concrete (inks) used in 3DCP consists of much more binders (mostly Portland cement) compared to conventional concrete, the increasing adoption of 3DCP is now speeding-up the consumption of cement in the construction sector. The innovation in the 3DCP inks needs to be accelerated to change the situation - greener inks need to be designed, produced, and supplied to the market more quickly. The carbon embodiment and other aspects, including energy consumption, the supply chain efficiency, the broader economic and environmental impacts, are seldom considered holistically in the life cycle design of most general-purpose concrete, not to mention the 3DCP concrete. The uncertainties associated with these aspects make it more challenging. Significant gaps exist between the material science, printer manufacturing, concrete producing, supply networks, governmental legislation and policies, and the 3DCP end users. Therefore, this convergence accelerator project will develop a novel framework, OpenMatFlo, for accelerating the convergence at the concrete industry and 3DCP nexus. The research can have fundamental socioeconomic impact by contributing to the innovation of new materials for the 3DCP industry. While the project context is focused on the 3DCP sector, the new capabilities can be ported to other areas. The project can provide transformational insights, cutting-edge simulation and data accessibility toolkits for the 3DCP community, as well as STEM education and research opportunities for a diverse cohort of students, postdocs, and early-career scientists. The society will benefit from the accelerated adoption of greener 3DCP, in terms of fighting against carbon emission and climate change. The platform will be scalable to the globe and extendable for other industries.

## TA7: Education and Workforce Development

### P64: Codebreakers: Cultivating Elementary Students’ Interest in Cryptography and Cybersecurity Education and Careers [NSF]

**Investigators:** Pasha Antonenko, Amber E Benedict, Swarup Bhunia, Kara Dawson

The growing capabilities of sensing, computing and communication devices are leading to an explosion of Internet of Things (IoT) infrastructures. In the meantime, advances in technologies such as autonomous systems and artificial intelligence promise enormous economic and societal benefits. Naturally, it is desirable to deploy these technologies in IoT infrastructures. However, such deployments present daunting changes for increasingly scaled-up IoT infrastructures in mission-critical applications such as medical, energy, transportation, and industrial-automation systems. These challenges stem from several major aspects in terms of scalability. First, the number of edge devices can be enormous, often in the order of billions, which makes centralized management infeasible. Second, there are multiple layers of heterogeneity. An IoT system can consist of heterogeneous computing subsystems; each subsystem can have heterogeneous computing devices; and each single device can be composed of different kinds of computing components. Third, mission-critical applications have stringent requirements in correctness, resilience, timeliness, security and safety. It is difficult for a large-scale IoT system to satisfy these requirements due to increasing opportunities for adversarial activity.

### P65: Peek Inside the Box: Gamified Learning of Computing Hardware Fundamentals

**Investigators:** Pasha Antonenko, Swarup Bhunia, Mary Jo Koroloy

Developing reliable and secure systems requires a deep understanding of the full software stack and the hardware architecture. Complexity of software and the hardware makes it very challenging to construct a comprehensive view of computing systems, which leads to overly optimistic assumptions about the software or the hardware. Despite recent advances in the decision procedures and the analysis techniques, hardware software co-verification is challenged by the scalability issue. Although run-time verification can be used potentially to overcome the scalability challenge, for embedded systems the success of runtime verification highly depends on the proper configuration. We propose a property-directed run-time verification approach that utilizes hardware software co-model extraction for improved bug detection capability, overhead, and precision.

### P66: Integrating AI Learning into Middle School Science through Natural Language Processing [NSF]

**Investigators:** Kristy Boyer, Mehmet Celepkolu

This project responds to the growing recognition that learners of all ages should have the opportunity to engage with and learn about artificial intelligence (AI). Of AI’s many subfields, natural language processing (NLP) is one of the fastest growing. NLP focuses on how to automatically understand spoken or textual data, and billions of these textual or spoken exchanges are recorded online every day. Historically, using NLP required extensive coding expertise and a deep understanding of machine learning, but recent advances and work by the project team have laid the foundation for bringing authentic, situated NLP learning into middle school classrooms. The project foregrounds how to teach NLP with ethics and ethical reasoning applied to relevant local issues and will investigate how to integrate AI learning through NLP into middle school science on weather systems and cycles through problem-based learning.

### P67: Fostering Computer Science and AI Learning through Youth-Led Conversational App Development Experiences [NSF]

**Investigators:** Kristy Boyer, Maya Israel

Computing skills are essential for 21st-century workforce development, and artificial intelligence (AI) is increasingly at the center of computationally rich careers. To remain at the forefront of global technology, the US needs a diverse workforce prepared with these skills. There is a tremendous pool of talented learners who are currently not given access to computer science and AI learning opportunities during the critical ages when they develop educational interests and career identities. Experiences during K-12 have a significant impact on those identities and resulting career path choices. This project will engage historically marginalized middle school students in Alachua County, Florida in a summer program that teaches them computer science and AI concepts. Through an authentic inquiry process centered on developing conversational AI, spoken technologies that engage users in conversation, students will investigate and create innovative computational applications. Young learners will have the opportunity to develop skills in the design and implementation of a variety of personally relevant projects including speech assistants, question-answering systems, and games. These projects can offer meaningful engagement that has the potential to transform the way middle school students view computing and AI careers.

### P68: Engaging High School Students in Computer Science with Co-creative Learning Companions [NSF]

**Investigators:** Kristy Boyer

Low-intensity focused ultrasound (FUS) is an emerging non-invasive and spatially/temporally precise method for modulating the firing rates and patterns of peripheral nerves. We are developing an image-guided wearable platform for chronic and patient-specific FUS neuromodulation. The platform uses functional feedback based on detecting muscle activation for real-time optimization of the acoustic energy delivered to the targeted nerve. The system uses custom body-conformal probes that contain separate ultrasound imaging and modulation arrays using piezoelectric transducers. The imaging array generates high quality B-mode images on both straight and curved surfaces that are analyzed using a template-matching algorithm or deep learning model to localize the target nerve and then direct the modulation beam towards the target. A portable FPGA-based Ultrasound scanning system will also be built and integrated with the platform to achieve point-of-care applications.

### P69: Fostering Collaborative Computer Science Learning with Intelligent Virtual Companions for Upper Elementary Students [NSF]

**Investigators:** Kristy Boyer

There is growing recognition that children can, and should, learn computer science. One of the central tenets of computer science is that it is a collaborative discipline, yet children do not start out with an intrinsic ability to collaborate. The project will provide the opportunity for upper elementary students to learn computer science and build strong collaboration practices. Leveraging the promise of virtual learning companions, the project will address three thrusts. First, the project will collect datasets of collaborative learning for computer science in diverse upper elementary school classrooms. Second, the project will design, develop, and iteratively refine its intelligent virtual learning companions, which support dyads of students in a scaffolded computer science learning environment with an interactive online coding tool. (continued on next page)



(continued from previous page) Third, the project will generate research findings and evidence about how children collaborate in computer science learning, and how best to support their collaboration with intelligent virtual learning companions. There will be three families of deliverables: learning activities and professional development, an intelligent learning environment with virtual learning companions, and research evidence that furthers the state of scholarship and practice surrounding the collaborative learning of computer science. The project will situate itself in highly diverse elementary schools in two states, Durham County, North Carolina and Alachua County, Florida. This project is supported by the Discovery Research PreK-12 program, which funds research and development of STEM innovations and approaches.

**P70: CAREER: Bridging Formal and Everyday Learning through Wearable Technologies: Towards a Connected Learning Paradigm [NSF]**

**Investigators:** Sharon Lynn Chu

A significant problem in science learning is that students do not always see the relevance of the concepts they are learning. This lack of perceived relevance may then lead to less student engagement in science. This project will investigate how to connect 4th to 6th grade students’ out-of-classroom, everyday experiences with formal in-classroom science instruction through the use of wearable and visualization technologies. Students will use wearable technologies to capture their everyday experiences related to science and reflect on these experiences through a web-based interface. A dashboard application will support teachers in tailoring their classroom science lesson plans accordingly. The project will contribute to our understanding of how to design wearable technologies for connecting learning across contexts and will inform a framework of teaching science that is better grounded in students’ everyday experiences with science concepts. Students from two highly diverse K-12 schools will participate in the project. Outcomes of the project will lead to the design of new structures for connected science learning that are responsive to diverse student experiences and backgrounds.

**P71: Collaborative Research: Innovating Quantum-Inspired Learning for Undergraduates in Research and Engineering [NSF]**

**Investigators:** Philip Feng, Jing Guo, Gloria Kim, Wanli Xing

This project aims to serve the national interest by developing a quantum information science and technology curriculum with experiential learning for undergraduate STEM students. Emerging quantum technologies promise to revolutionize computing, communication, networking, and sensing in unconventional ways and with information security. This has created a need for a new generation of engineers, scientists, and programmers who can apply quantum science and technology principles in the STEM workforce. The multidisciplinary nature of quantum technologies poses challenges to providing a comprehensive education for students from different degree programs who may lack the technical background in some areas. This project aims to lower entry barriers for students, to develop transferable skillsets for quantum computing and engineering, to generate knowledge about conditions for creative teaching and effective student learning in this multidisciplinary field, and to prepare students for entering this rapidly emerging field. The success of this project should lead to large numbers of undergraduate engineering and science students equipped with essential quantum knowledge and skills and a new quantum education program adaptable for undergraduate STEM students at other institutions.

**P72: UF GenCyber Hybrid Program: Rural Ace: Rural High School Students Access to Cybersecurity Education in the Age of AI**

**Investigators:** Wanli Xing, Sandip Ray, Mary Jo Koroly, Swarup Bhunia

This project provides cybersecurity experiences for students to ignite, sustain, and increase diversity and explore career options in this area critical to national security.

**P73: Collaborative Research: Fostering Virtual Learning of Data Science Foundations with Mathematical Logic for Rural High School Students [NSF]**

**Investigators:** Wanli Xing

Data science is revolutionizing science and industry, and the current job market has shown a strong demand for a workforce fluent in data science. The LogicDataScience (LogicDS) curriculum in the Florida Virtual Schools (FLVS) is introducing high school students to this exciting area and related careers. The project addresses a major educational barrier, namely that rural students are less likely to choose a major in STEM and have far less access to advanced STEM courses taught by highly qualified teachers. The LogicDS curriculum and virtual delivery are expected to relieve the resource constraints significantly and thus reach rural students. The strategy behind this curriculum development for data science explores the utility of emphasizing how the foundations of data science in computing, mathematics, and statistics are unified by mathematical logic. The project is studying the impacts of the new curriculum on students’ learning of computing, mathematics, and statistics.

**P74: A Culturally Relevant Approach to Spatial Computational Thinking Skills and Career Awareness through an Immersive Virtual Environment [NSF]**

**Investigators:** Wanli Xing

The project will design and research a project for developing upper-elementary Latinx students’ spatial computational thinking skills and awareness of computationally-intensive careers. The project will design immersive, culturally relevant, and active learning experiences in Minecraft: Education Edition (MEE). Minecraft, which is used by millions worldwide, enables participants to explore a three-dimensional world, discover and use raw materials, engineer new environments, create tools and structures, and simple machines. This video game platform emphasizes family engagement, near-peer mentorship, peer collaboration, and expert modeling. The project will develop a unique set of extended and age-appropriate spatial programming functions and engage participants in developing Spatial Computational Thinking Skills (SCT). These skills will support the ability to learn to abstract key spatial features, to decompose shapes with geometric representation and recognize patterns, and to use programming and computing tools for spatial algorithm design. The project will introduce participants to computationally-intensive STEM careers where these skills are increasingly demanded in areas such as robotics, virtual reality, and smart geospatial systems. The project will develop a unique set of bilingual, extended and age-appropriate visual programming functions to enable thousands of upper elementary school students to engage in high-quality spatial programming learning experiences. Participants will be able to access the game in school or at home. Due to low-cost materials and the self-paced learning design, the learning activities are flexible and affordable for families and educators who have different needs.

TA8: Neuro-engineering

P75: Mechanisms, response heterogeneity and dosing from MRI-derived electric field models in tDCS augmented cognitive training: a secondary data analysis of the ACT study [NIH]

Investigators: Adam J. Woods, Ruogu Fang

There is a pressing need for effective interventions to remediate age-related cognitive decline and alter the trajectory toward Alzheimer’s disease. The NIA Alzheimer’s Disease Initiative funded Phase III Augmenting Cognitive Training in Older Adults (ACT) trial aimed to demonstrate that transcranial direct current stimulation (tDCS) paired with cognitive training could achieve this goal. The present study proposes a state of the art secondary data analysis of ACT trial data that will further this aim by 1) elucidate mechanism of action underlying response to tDCS treatment with CT, 2) address heterogeneity of response in tDCS augmented CT by determining how individual variation in the dose of electrical current delivered to the brain interacts with individual brain anatomical characteristics; and 3) refine the intervention strategy of tDCS paired with CT by evaluating methods for precision delivery targeted dosing characteristics to facilitate tDCS augmented outcomes. tDCS intervention to date, including ACT, apply a fixed dosing approach whereby a single stimulation intensity (e.g., 2mA) and set of electrode positions on the scalp (e.g., F3/F4) is applied to all participants/patients. However, our recent work has demonstrated that age-related changes in neuroanatomy as well as individual variability in head/brain structures (e.g., skull thickness) significantly impacts the distribution and intensity of electrical current induced in the brain from tDCS. This project will use person-specific MRI-derived finite element computational models of electric current characteristics (current intensity and direction of current flow) and new methods for enhancing the precision and accuracy of derived models to precisely quantify the heterogeneity of current delivery in older adults. We will leverage these individualized precision models with state-of-the-art support vector machine learning methods to determine the relationship between current characteristics and treatment response to tDCS and CT. We will leverage the inherent heterogeneity of neuroanatomy and fixed current delivery to provide insight in the not only which dosing parameters were associated with treatment response, but also brain region specific information to facilitate targeted delivery of stimulation in future trials. Further still, the current study will also pioneer new methods for calculation of precision dosing parameters for tDCS delivery to potentially optimize treatment response, as well as identify clinical and demographic characteristics that are associated with response to tDCS and CT in older adults. Leveraging a robust and comprehensive behavioral and multimodal neuroimaging data set for ACT with advanced computational methods, the proposed study will provide critical information for mechanism, heterogeneity of treatment response and a pathway to refined precision dosing approaches for remediating age- related cognitive decline and altering the trajectory of older adults toward Alzheimer’s disease.

P76: III: Small: Modeling Multi-Level Connectivity of Brain Dynamics [NSF]

Investigators: Ruogu Fang, Mingzhou Ding

The temporal dynamics of blood flows through the network of cerebral arteries and veins provides a window into the health of the human brain. Since the brain is vulnerable to disrupted blood supply, brain dynamics serves as a crucial indicator for many kinds of neurological diseases such as stroke, brain cancer, and Alzheimer’s disease. Existing efforts at characterizing brain dynamics have predominantly centered on ‘isolated’ models in which data from single-voxel, single-modality, and single-subject are characterized. (continued on next page)

(continued from previous page) However, the brain is a vast network, naturally connected on structural and functional levels, and multimodal imaging provides complementary information on this natural connectivity. Thus, the current isolated models are deemed not capable of offering the platform necessary to enable many of the potential advancements in understanding, diagnosing, and treating neurological and cognitive diseases, leaving a critical gap between the current computational modeling capabilities and the needs in brain dynamics analysis. This project aims to bridge this gap by exploiting multi-scale structural (voxel, vasculature, tissue) connectivity and multi-modal (anatomical, angiography, perfusion) connectivity to develop an integrated connective computational paradigm for characterizing and understanding brain dynamics.

P77: Web-based Automated Imaging Differentiation of Parkinsonism [NIH]

Investigators: David Vaillancourt, Angelos Barmpoutis, Michael Okun, Stefan Prokop, Ruogu Fang, Samuel Wu, Nikolaus McFarland, Adolfo Ramirez-Zamora

The three distinct neurodegenerative disorders — Parkinson’s disease; multiple system atrophy Parkinsonian variant, or MSAp; and progressive supranuclear palsy, or PSP — can be difficult to differentiate because they share overlapping motor and non-motor features, such as changes in gait. But they also have important differences in pathology and prognosis, and obtaining an accurate diagnosis is key to determining the best possible treatment for patients as well as developing improved therapies of the future. Previous research has shown that accuracy of diagnosis in early Parkinson’s can be as low as 58%, and more than half of misdiagnosed patients actually have one of the two variants. Testing of the new AI tool, which will include MRI images from 315 patients at 21 sites across North America, builds upon more than a decade of research in the laboratory of David Vaillancourt, Ph.D., a professor and chair of the UF College of Health & Human Performance’s department of applied physiology and kinesiology, whose work is focused on improving the lives of more than 6 million people with Parkinson’s disease and Parkinson’s-like syndromes. To differentiate between the forms of Parkinsonism, Vaillancourt’s lab has developed a novel, noninvasive biomarker technique using diffusion-weighted MRI, which measures how water molecules diffuse in the brain and helps identify where neurodegeneration is occurring. Vaillancourt’s team demonstrated the effectiveness of the technique in an international, 1,002- patient study published in The Lancet Digital Health in 2019.

P78: VCA-DNN: Neuroscience-Inspired Artificial Intelligence for Visual Emotion Recognition [NIH]

Investigators: Ruogu Fang, Mingzhou Ding

Human emotions are dynamic, multidimensional responses to challenges and opportunities, which emerge from network interactions in the brain. Disruptions of these network interactions underlie emotional dysregulation in many mental disorders including anxiety and depression. In the process of carrying out our current NIH funded research on how human brain processes emotional information, we recognize the limitation of empirical studies, including not being able to manipulate the system to establish the causal basis for the observed relationship between brain and behavior. Creating an AI-based model system that is informed and validated by known biological findings and that can be used to carry out causal manipulations and allow the testing of the consequences against human imaging data will thus be a highly significant development in the short term. In the long term, the model can be further enriched and expanded so that it becomes a platform for testing a wider range of normal brain functions, as well as a platform for testing for how various pathologies affect these functions in mental disorders.



**P79: Collaborative Research: SCH: Trustworthy and Explainable AI for Neurodegenerative Diseases [NSF]**

**Investigators:** My T. Thai, Ruogu Fang, Adolfo Ramirez-Zamora

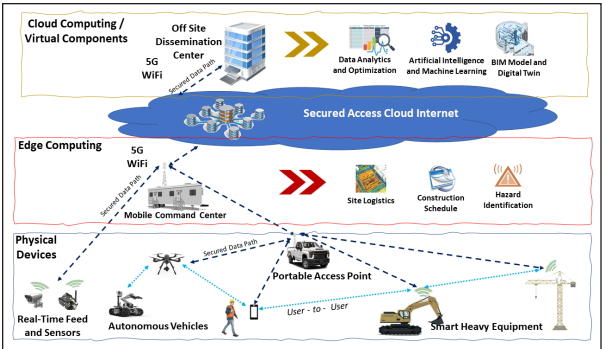
Driven by its performance accuracy, machine learning (ML) has been used extensively for various applications in the healthcare domain. Despite its promising performance, researchers and the public have grown alarmed by two unsettling deficiencies of these otherwise useful and powerful models. First, there is a lack of trustworthiness - ML models are prone to interference or deception and exhibit erratic behaviors when in action dealing with unseen data, despite good practice during the training phase. Second, there is a lack of interpretability - ML models have been described as 'black-boxes' because there is little explanation for why the models make the predictions they do. This has called into question the applicability of ML to decision-making in critical scenarios such as image-based disease diagnostics or medical treatment recommendation. The ultimate goal of this project is to develop computational foundation for trustworthy and explainable Artificial Intelligence (AI), and offer a low-cost and non-invasive ML-based approach to early diagnosis of neurodegenerative diseases. In particular, the project aims to develop computational theories, ML algorithms, and prototype systems. The project includes developing principled solutions to trustworthy ML and making the ML prediction process transparent to end-users. The later will focus on explaining how and why an ML model makes such a prediction, while dissecting its underlying structure for deeper understanding. The proposed models are further extended to a multi-modal and spatial-temporal framework, an important aspect of applying ML models to healthcare. A verification framework with end-users is defined, which will further enhance the trustworthiness of the prototype systems. This project will benefit a variety of high-impact AI-based applications in terms of their explainability, trustworthy, and verifiability. It not only advances the research fronts of deep learning and AI, but also supports transformations in diagnosing neurodegenerative diseases.

**TA9: Urban and Regional Planning**

**P80: Elements: Cyberinfrastructure Service for IoT-Based Construction Research and Applications**

**Investigators:** Aaron Costin, Janise McNair, Sanjeev Koppal, Idris Jeelami

This project develops a robust cyberinfrastructure (CI) system and service for construction research and applications to address the current challenges faced in the construction industry. The outcomes and services that this project aims to provide are 1) a distributed SDN-managed and AI-assisted IoT based system that can be adapted and extended based on needs of the research and application; 2) identification of the data and data security requirements needed to address the challenges in the construction industry and potential technologies that can provide those data; 3) evaluation of reliable realtime multi-sensor fusion techniques for ruggedness, usability, and limitations of IoT-based components deployed in the dynamic construction environments; 4) robust prototype system for real-time safety monitoring based on the IoT system framework; and 5) recommendations of potential configurations of the system with the appropriate technology and sensors to meet the needs of the application. The system is named IoT-ACRES, short for IoT-Applied Construction Research and Education Services.



**P81: Collaborative Research: A Dynamic Disruption Prediction System for Transportation Networks at a Road-Segment Level of Granularity [NSF]**

**Investigators:** Mostafa Reisi Gahrooei

This grant will develop theoretical foundations and empirically test the feasibility of a novel framework for real-time monitoring and disruption prediction of road transportation networks during extreme events at a road-segment level of granularity. Recent natural disasters have shown that road transportation networks mainly fail due to unexpected gridlocks resulting from unusual traffic patterns. These disruptions adversely affect emergency management processes such as evacuations, rescue, and recovery operations. Prompt prediction of disruptions is vital for a successful emergency management system, but despite this critical need, emergency management processes still lack real-time network monitoring and prediction methods for transportation systems. Real-time monitoring and disruption prediction of road networks creates opportunities to develop proactive emergency management systems that lead to efficient, fast, and successful rescue and recovery operations. The benefits of more efficient and successful emergency management operations will be passed down to the public and will result in enhanced quality of life, health, and well-being for commuters and other infrastructure users. Ultimately, this project will contribute to developing sustainable and resilient cities and communities that can function properly even under the stress of extreme events. In connection with this project, educational and outreach efforts are envisioned for integration into undergraduate and graduate courses. This grant will provide an opportunity for project-based learning for K-12, undergraduate, and graduate students, especially minorities and under-represented groups.

**P82: SCC-PG: SmartCurb: Building Smart Urban Curb Environments [NSF]**

**Investigators:** Yan Wang, Lili Du, Shigang Chen

U.S. cities are witnessing an era of transformative innovations in electric vehicles (EVs), autonomous vehicles, on-vehicle electronics, Global Position System, mobile devices, digital maps, and numerous apps that assist driving and parking. However, the advance in curb environments where vehicles operate has not kept pace. Curb environments serve as a unique nexus that connects on-road traffic and pedestrian sidewalks across urban communities, but are burdened in urban cores due to space competition for pick-ups and drop-offs, freight loading, EVs charging, bicycle, and scooter parking. This NSF Smart & Connected Community planning grant studies curbside environments at the downtown and University of Florida (UF) campus communities in the City of Gainesville, Florida. It focuses on how to integrate vehicles, people, mobile devices, physical and cyber infrastructures to coordinate curb space uses. Collectively, these innovations will maximize equitable and convenient access while minimizing greenhouse gas emissions for healthy and sustainable communities, relieving congestion at curb spaces, and boosting livability for community residents. The project explores important, emerging challenges faced by cities across America. The knowledge learned will be shared with local communities, who will benefit in the long term, to prepare city curbs for future burgeoning technology and mobility innovations. The project seeks to understand curb space uses of urban communities and to develop strategic management to adapt increasingly diverse and conflicting curb space uses in response to emerging vehicular technologies and mobility innovations.

## TA10: Consumer Electronics

### P83: Magnetic Field Emission and Reduction for Magnetic Components

Investigators: Shuo Wang

Magnetic components such as inductors and transformers are widely used in power electronics, digital electronics, and small-signal analog circuit applications. These magnetic components can generate both near field and far field EM radiation which leads to both conductive and radiated electromagnetic interference (EMI). The EMI can violate FCC limits and causing safety and reliability troubles. Studying the impacts of winding shapes, magnetic materials, and switching voltages to the radiation can help to minimize the EM radiation and keep a clean EMI-free environment.

### P84: Collaborative Research: SHF: Small: Towards Variability-Aware Software Analysis and Testing [NSF]

Investigators: Tuba Yavuz

Much of the software upon which society depends is highly configurable, with many optional and alternative features that can be turned on or off. Some combinations of options “play well” together. Other combinations of options may cause the software to crash or behave incorrectly and must be avoided. A wrong variety of features can be dangerous in safety-critical applications, such as in the health or aerospace domains. As software becomes more complex and offers more features, the risk of disconnects increases between those combinations that are disallowed per the requirements specifications and those constraints that are actually implemented in the code. The project will enable more effective analysis and testing of software product lines and configurable systems compared to the state-of-the-art. It will train students in the increasingly automated software analysis needed to verify complex, highly configurable software systems and product lines.

### P85: NSF Convergence Accelerator Track I: Energy-efficient MetaConductors for Convergence of Sustainable Electronics (E-MC2 of Sustainable Electronics) [NSF]

Investigators: YK Yoon, Jin Choi, Gloria Kim, Jeongwon Park

Due to a decades-long lack of onshore manufacturing capability and supply chain inequality, the United States (US) suffers from a critical shortage of semiconductor chips and electronic parts. Consequently, the US electronics industry is currently in an unsustainable situation and faces a major economic and national security threat. The goal of this work is to explore Energy-efficient MetaConductors for Convergence of Sustainable Electronics (E-MC2 Sustainable Electronics) for future society and develop manufacturing technologies to translate metaconductors to commercial use to meet the signal/power integrity requirements for modern high-speed, broadband electronic applications. E-MC2 Sustainable Electronics will generate multiple key areas of intellectual property in the manufacturable metaconductor technology space, establishing the US as the leader in both technology and accelerating technology transfer to launch startups and adoption by industry, thus contributing to the growth of the economy and job creation. The multi-disciplinary and multi-institutional team will leverage its previous collaborations, new insights from new alliances, and collective experience in engineering education. The outcome of the inclusive educational activities will be a diverse, well-trained, and globally competent workforce in semiconductor manufacturing and related fields.

## TA11: Smart Energy

### P86: Collaborative Research: CPS: Medium: Adaptive, Human-centric Demand-side Flexibility Coordination At-scale in Electric Power Networks [NSF]

Investigators: Jie Fu

Active user participation in large-scale infrastructure systems, while presenting unprecedented opportunities, also poses significant challenges for the operator. One such example is electric power distribution systems, where the massive integration of distributed energy resources (DERs) and flexible loads motivates new decision-making paradigms via demand response through user engagement. This project introduces a novel approach for intelligent decision making in power distribution systems to efficiently leverage flexible demand commitments in highly uncertain and stochastic environments. The project goals are to (1) develop analytics required to enable actionable demand-side flexibility from several small consumers by adequately representing their constraints regarding electricity usage and their interactions with the system and the energy provider; and (2) develop a prototype for demand-side coordination using an open-source testbed for distribution systems management and evaluate the proposed algorithms with real-world utility data. Successful completion of this project will provide solutions to adaptive and smart infrastructure systems in which passive users turn into active participants. For the demand response focus here, this project will enable high levels of penetration of flexible loads and DERs economically through the transformation of grid operation from load following to supply following. The results from this project will provide valuable guidance to policymakers and electric utilities in managing aggregator-driven markets.

### P87: Energy Efficiency Improvement for Wireless Power Transfer / charging

Investigators: Shuo Wang

Wireless power transfer can give people more freedom to move. The energy transfer efficiency can help reduce the charging/transfer time. EM field from both the transmitter coil and receiver coil leads to eddy current power loss. Furthermore, due to the unmatched charging load, the wireless power transfer cannot achieve the high power transfer. Exploring the power loss due to the eddy current power loss and optimize the transmitter and receiver coil design can improve energy conversion efficiency. Developing optimal load matching systems can maximize the transferred power and reduce the transfer / charging time.



# FACULTY BIOS



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Dr. Swarup Bhunia is the Director of the Warren B. Nelms Institute and Professor in the Department of Electrical and Computer Engineering (ECE) at the University of Florida. Dr. Bhunia received his B.E. (Hons.) from Jadavpur University, Kolkata, India, M.Tech. from the Indian Institute of Technology (IIT), Kharagpur, and Ph.D. from Purdue University, IN, USA. He co-cofounded the first-ever journal on hardware security, Journal of Hardware and Systems Security (HaSS). He currently leads research effort in Nanoscape, the nanocomputing research laboratory at the University of Florida. His other research interests include food and medicine safety, adaptive and energy-efficient computing, and wearable and implantable systems.



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Dr. My T. Thai is a UF Research Foundation Professor of Computer & Information Sciences & Engineering and Associate Director of Warren B. Nelms Institute for the Connected World at the University of Florida. Dr. Thai has extensive expertise in trustworthy AI, billion-scale data mining, and optimization, especially for complex graph data with applications to blockchain, social media, critical networking infrastructure, cybersecurity, and healthcare. The results of her work have led to 7 books and 300+ publications in leading academic journals and conferences, including 2014 IEEE MSN Best Paper Award, 2017 IEEE ICDM Best Papers Award, 2018 IEEE/ACM ASONAM Best Paper Runner Up, and 2023 AAAI Distinguished Paper Award.



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Dr. Pavlo "Pasha" Antonenko is an Associate Professor of Educational Technology and Director of the NeurAL Lab in the School of Teaching and Learning at the University of Florida. He earned his Specialist degree in teaching English and German language and literature and Masters in Linguistics at Nizhyn Gogol State University in Ukraine. In 2007 he defended his dissertation and graduated with a PhD in a) Curriculum and Instructional Technology and b) Human-Computer Interaction from Iowa State University. He was fortunate to work with Drs. Dale Niederhauser and Ann Thompson as his co-advisers and grow as a researcher in the Center for Technology in Learning and Teaching and Virtual Reality Applications Center. His dissertation focused on the use of link comments when learning in a nonlinear conceptually rich hypertext environment.



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Dr. Zoleikha Biron is currently an Assistant Professor in the Electrical and Computer Engineering (ECE) Department at the University of Florida. Her research focuses on cyber physical systems with applications in intelligent transportation systems, smart power systems and integration of renewable energy sources with smart power systems. She is interested in utilizing control theory, estimation and fault diagnostics techniques to enhance the security and efficiency of cyber physical systems. She received her Ph.D. at Clemson University in 2017, her MS and BS degree in Electrical Engineering from K.N. Toosi University of Technology and University of Tehran, respectively. Prior to joining University of Florida in Jan 2019, she spent 18 months at Clemson University international center of automotive research (CU\_ICAR) as a post doc.



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Dr. Christophe Bobda is a Professor in the Department of Electrical and Computer Engineering. Professor Bobda received the Licence in mathematics from the University of Yaounde, Cameroon, in 1992, the diploma of computer science and the Ph.D. degree (with honors) in computer science from the University of Paderborn in Germany in 1999 and 2003 (In the chair of Prof. Franz J. Rammig) respectively. In June 2003 he joined the department of computer science at the University of Erlangen-Nuremberg in Germany as Post doc, under the direction of Prof Jargen Teich. Professor Bobda is Senior Member of the ACM. He is also in the program committee of several conferences (FPL, FPT, RAW, RSP, ERSa, RECOsoc, DRS), the DATE executive committee as proceedings chair (2004, 2005, 2006, 2007, 2008, 2009, 2010).



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Dr. Kristy Elizabeth Boyer is a Professor in the Department of Computer & Information Science & Engineering and the Department of Engineering Education at the University of Florida. Her research focuses on how natural language dialogue and intelligent systems can support human learning across educational contexts including within and outside the classroom. Boyer holds a Ph.D. in Computer Science from North Carolina State University, an M.S. in Applied Statistics from the Georgia Institute of Technology, and a B.S. in Mathematics and Computer Science from Valdosta State University. She has been recognized with an NSF CAREER award and an NSF Graduate Research Fellowship.





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Dr. Chen received his M.S. and Ph.D. degrees in Computer Science from University of Illinois at Urbana-Champaign in 1996 and 1999, respectively. Prior to that, he received a B.S. degree in Computer Science from University of Science and Technology of China in 1993. After graduating from UIUC, he worked with Cisco Systems on network security for three years and helped start a network security company, Protego Networks. He joined University of Florida as an assistant professor in 2002, and was promoted to associate professor in 2008 and to professor in 2013. He was a recipient of IEEE Communications Society Best Tutorial Paper Award in 1999, NSF CAREER Award in 2007, and Cisco University Research Award in 2007, 2012. He published 200+ peer-reviewed journal/conference papers and has 13 US patents.



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Dr. Sharon Lynn Chu is an Assistant Professor in the Department of Computer and Information Science and Engineering (CISE). She leads the Embodied Learning & Experience (ELX) Lab [pronounced 'el-x'] research group. The ELX lab conducts research in two main broad areas: learning technologies and technologies for health and well-being. All in all, we study human behavior in technological contexts. Dr. Chu received her B.Soc.Sci (1st Class Honors) in Communication and New Media from the National University of Singapore, her MS in Computer Science & Applications and a graduate certificate in Human-Computer Interaction from Virginia Tech, and her Ph.D in Human-Computer Interaction from Texas A&M University.



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Dr. Aaron Costin is an Associate Professor at the M.E. Rinker, Sr. School of Construction Management at the University of Florida. He holds a Bachelor of Science (B.S.), Master of Science (M.S.), and Doctor of Philosophy (Ph.D.) in Civil Engineering from the Georgia Institute of Technology. Dr. Costin leads the Smart Construction Informatics (SCI) laboratory where they research emerging technologies and interoperability for the built environment. Recently, Dr. Aaron Costin and his team was awarded a \$455k National Science Foundation (NSF) grant to support the research of the development a state-of-the-art Intelligent Jobsite using the Internet of Things (IoT), Artificial Intelligence (AI), and other recent innovations.



**Lili Du**

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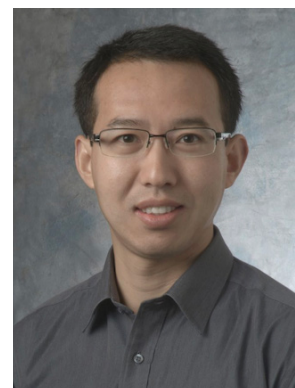
Dr. Lili Du is an Associate Professor in the Department of Civil and Coastal Engineering. Before joining UF, she worked as an assistant and then an associate professor at Illinois Institute of Technology from 2012-2017. She also worked as a Post-doctoral Research Associate for NEXTRANS, the USDOT Region V Regional University Transportation Center at Purdue University from 2008 to 2012. Dr. Du received her Ph.D. degree in Decision Sciences and Engineering Systems with a minor in Operations Research and Statistics from Rensselaer Polytechnic Institute in 2008. Du's research is characterized by applying operations research, network modeling, and statistical methods into transportation system analysis and network modeling.



**Ruogu Fang**

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An AI researcher in medicine and healthcare, Dr. Ruogu Fang is a tenured Associate Professor and Pruitt Family Endowed Faculty Fellow in the J. Crayton Pruitt Family Department of Biomedical Engineering at the University of Florida. Her research theme is artificial intelligence (AI)-empowered precision brain health and brain/bio-inspired AI. She focuses on questions such as: How to use machine learning to quantify brain dynamics, early diagnose Alzheimer's disease through novel imagery, predict individualized treatment outcomes, and design precision intervention. Fang's current research is rooted in the confluence of AI and multimodal medical image analysis. She is the PI of NIH NIA RF1 (R01-equivalent), NSF Research Initiation Initiative (CRII) Award, NSF CISE IIS Award, Ralph Lowe Junior Faculty Enhancement Award from Oak Ridge Associated Universities (ORAU).



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Dr. Philip Feng is a Professor & Associate Chair for Research in the Department of Electrical & Computer Engineering (ECE). His research interests include solid-state devices, nanoelectromechanical Systems (NEMS), Quantum Engineering, and nanotechnology. Dr. Feng received the Presidential Early Career Award for Scientists and Engineers (PECASE) in 2019, the National Science Foundation (NSF) CAREER Award in 2015, the National Academy of Engineering (NAE) Grainger Foundation Frontiers of Engineering Award in 2014, and was one of 81 Young Engineers Selected to National Academy of Engineering (NAE) Frontier of Engineering Symposium in 2013.





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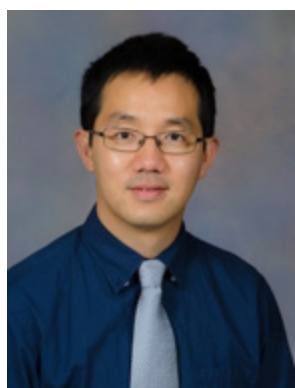
Dr. Jie Fu is an Assistant Professor with the Department of Electrical and Computer Engineering. She was named a Nelms Rising Star Professor in 2023. She received the M.Sc. degree in Electrical Engineering and Automaton from Beijing Institute of Technology, Beijing, China, in 2009, and the Ph.D. degree in Mechanical Engineering from the University of Delaware, Newark, DE, USA, in 2013. From 2013 to 2015, she was a Postdoctoral Scholar with the University of Pennsylvania. From 2016-2021, she was an Assistant Professor with the Department of Robotics Engineering, with an affiliation in Dept. of ECE, at Worcester Polytechnic Institute, Worcester, MA. Her research interests include Control theory, Game theory, and Formal methods.



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Dr. Mostafa Reisi received his master's degree in computational science and engineering and his Ph.D. degree in industrial and systems engineering from Georgia Institute of Technology, and the M.Sc. degrees in transportation engineering and applied mathematics from the Southern Illinois University Edwardsville. He is currently an Assistant Professor with the Department of Industrial and Systems Engineering at the University of Florida. His research interests focus on developing efficient methodologies and algorithms for modeling and monitoring systems through the fusion of high-dimensional and multimodal data. The applications of his work are in precision agriculture, manufacturing, healthcare, and transportation systems. He is a co-director of Data Informatics for Systems Improvement and Design (DISIDE) lab.



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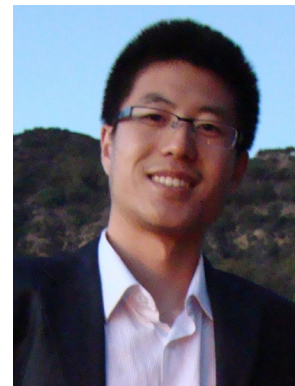
Dr. Jing Guo is a Professor in the Department of Electrical and Computer Engineering. His research interests include modeling and simulation of nanoelectronic devices, theory of nanoscale transistors, nanoscale memory devices and Quantum Computing devices, and device-circuit co-design in nanoelectronics. He received a National Science Foundation CAREER Award in 2009. Dr. Guo joined ECE at University of Florida in 2004 as an assistant professor. He received his Ph.D. from School of ECE at Purdue University in 2004.



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Dr. Matthew Hale is an Assistant Professor in Mechanical and Aerospace Engineering. He received his BSE summa cum laude from the University of Pennsylvania in 2012, and he received his MS and PhD from Georgia Tech in 2015, and 2017, respectively. He has been with the UF MAE Department since 2017. His research is broadly in the areas of control and optimization, with a strong emphasis on multi-agent systems and applications to robotics. The overall goal is to develop new theoretical tools that solve fundamental, practical problems in multi-agent systems. The intent of doing so is to enable safe, reliable, and efficient operation of multi-agent systems across a wide spectrum of applications. His recent awards include the MAE Department Teacher of the Year (for 2018-2019), MAE Department Researcher of the Year (for 2022-2023), an NSF CAREER Award in 2020, an ONR YIP in 2022, and an AFOSR YIP in 2023.



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Dr. Zhe Jiang is an Assistant Professor in the Department of Computer & Information Science & Engineering at the University of Florida, where he is also affiliated with the Center for Coastal Solutions. He received his Ph.D. in Computer Science from the University of Minnesota in 2016 and a B.E. in Electrical Engineering from the University of Science and Technology of China in 2010. His research interests include data mining, machine learning, and artificial intelligence, with a particular focus on spatiotemporal data mining for interdisciplinary applications in Earth sciences (hydrology, natural disaster, coastal hazards), agriculture, transportation, health and medicine, etc. His research has been sponsored by multiple federal agencies (e.g., NSF, USGS, NOAA, UCAR) and industry companies. He is a senior member of IEEE.



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Dr. Sanjeev J. Koppal is an Associate Professor at the Electrical and Computer Engineering Department and is a Kent and Linda Fuchs Faculty Fellow. He also held a UF Term Professorship for 2021-23. Sanjeev is the Director of the FOCUS Lab at UF. Since 2022, Sanjeev has been an Amazon Scholar with Amazon Robotics. Prior to joining UF, he was a researcher at the Texas Instruments Imaging R&D lab. Sanjeev obtained his Masters and Ph.D. degrees from the Robotics Institute at Carnegie Mellon University. After CMU, he was a postdoctoral research associate in the School of Engineering and Applied Sciences at Harvard University. He is a co-author on best student paper awards for ECCV 2016 and NEMS 2018, and work from his FOCUS lab was a CVPR 2019 best-paper finalist. Sanjeev won an NSF CAREER award in 2020 and is an IEEE Senior Member and an Optica Senior Member. His interests span computer vision, computational photography and optics, novel cameras and sensors, 3D reconstruction, physics-based vision, and active illumination.





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Dr. Mary Jo Koroly is a Research Associate Professor in the Department of Biochemistry and Molecular Biology in the College of Medicine and the Director of the University of Florida Center for Precollegiate Education and Training (UF CPET) in Academic Affairs. Dr. Koroly's research interests are in the areas of cell regulation, membrane biochemistry, and science education. Prior to joining UF, she obtained her Ph.D. in Biochemistry from Bryn Mawr College, completed a postdoctoral fellowship at the University of Minnesota, and served on the faculty at Harvard Medical School and Bryn Mawr College. At UF, she directed the Medical School Biochemistry course for 22 years and was the founding director for the Interdisciplinary Center for Biotechnology Research Education and Training Core.



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Dr. Janise McNair is an Associate Professor of electrical & computer engineering at the University of Florida (ECE Florida). She is a researcher in the field of wireless networks and Internet of Things applications. Currently, her research creates frameworks for integrating IoT with 5G and 6G cellular systems. She was a pioneer in early next generation mobility management for cellular systems and later has focused on the development of multi-discipline, cross-layer systems for smart grid security analysis, IoT systems for construction site safety and security, and IoT systems for agriculture and food safety. She is currently a member of the Intelligence, Science and Technology Experts Group of the National Academies of Sciences Engineering and Medicine, the Integrity Committee of the IEEE Computer society, and was a participant in the 2008 DARPA Computer Science Study Group.



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Dr. Sara Rampazzi is an Assistant Professor at the Department of Computer & Information Science & Engineering (CISE) at the University of Florida. Her research areas focus on cyber-physical systems security, embedded systems design, modeling, and simulation with applications in Healthcare, Autonomous Systems, and the Internet of Things. Dr. Rampazzi investigates security and privacy risks and designs defense strategies for trustworthy and resilient cyber-physical systems despite emerging attacks. Several media outlets covered her work on injecting inaudible and invisible commands into smart home devices Light Commands. Forbes has recognized her work on Lidar spoofing attacks on autonomous vehicles as the first paper on practical attacks against LiDAR systems. Dr. Rampazzi has received the Medtronic Outstanding Research Contributor Recognition for medical device security, and her work has been sponsored by NSF, Meta, and Toyota Info Tech Lab.



**Sandip Ray**

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Dr. Sandip Ray is an Endowed IoT Term Professor at the Department of Electrical and Computer Engineering. His research involves developing correct, dependable, secure, and trustworthy computing through cooperation of specification, synthesis, architecture and validation technologies. He focuses on next generation computing applications, including IoT applications, autonomous automotive systems, smart homes, intelligent implants, etc. Before joining University of Florida, Dr. Ray was a Senior Principal Engineer at NXP Semiconductors, where he led the R&D on security architecture and validation of hardware platforms for automotive and IoT applications. Prior to that, he was a Research Scientist at Intel Strategic CAD Labs, where he led research on pre-silicon and post-silicon validation technologies for security and functional correctness of SoC designs, and design-for-security and design-for-debug architectures.



**Aditya Singh**

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Dr. Aditya Singh began as an Assistant Professor of Remote Sensing in the Department of Agricultural and Biological Engineering at the University of Florida in 2017. Previously, Dr. Singh obtained his Ph.D. in Forestry from the University of Wisconsin-Madison and an M.S. from the Wildlife Ecology and Conservation Department of the University of Florida. Aditya specializes in the application of optical remote sensing science in support of landscape-scale research on forest health, agricultural irrigation water management, assessment of pest and disease stress and occurrence, and food security in developing nations. A major part of Aditya's research involves developing tools and techniques for utilizing measurements obtained from combinations of contact (leaf-level), proximal (canopy-scale) and landscape-scale satellite and imaging spectroscopy data to assess plant nutrient status, health, and functioning.



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Dr. Greg Stitt is a Professor in the Department of Electrical and Computer Engineering. His research interests include reconfigurable computing, FPGAs, GPUs, synthesis, compilers, CAD, architecture, embedded systems. Some of his current research projects involve elastic computing and Intermediate Fabrics (FPGA Device Virtualization). He received his PhD in Computer Science from University of California-Riverside in 2007 and his BS in Computer Science from University of California-Riverside in 2000.





### **Daisy Wang**

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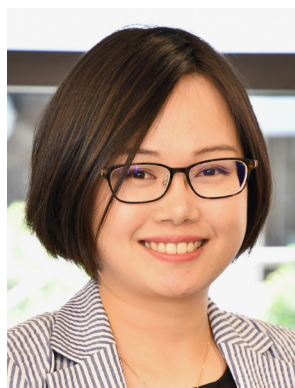
Dr. Daisy Zhe Wang is an Associate Professor in the CISE department. She is the Director of the Data Science Research Lab at UF. She obtained her Ph.D. degree from the EECS Department at the University of California, Berkeley in 2011 and her Bachelor's degree from the ECE Department at the University of Toronto in 2005. At Berkeley, she was a member of the Database Group and the AMP/RAD Lab. She is particularly interested in bridging scalable data management and processing systems with probabilistic models and statistical methods. She currently pursues research topics such as probabilistic databases, probabilistic knowledge bases, large-scale inference engines, query-driven interactive machine learning, and crowd assisted machine learning. She received Google Faculty Award in 2014. Along with other co-authors, she received "10-Years Test-of-Time" Award for the 2018 VLDB paper on WebTables.



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Dr. Shuo Wang (S'03-M'06-SM'07-F'19) received the Ph.D. degree in Electrical Engineering from Virginia Tech, Blacksburg, VA, in 2005. He is currently a full professor with the Department of Electrical and Computer Engineering, University of Florida. He has published more than 200 IEEE journal and conference papers and holds around 30 pending/issued US/international patents. He was the recipient of the Best Transaction Paper Award from the IEEE Power Electronics Society in 2006, two William M. Portnoy Awards for the papers published in the IEEE Industry Applications Society in 2004 and 2012, respectively, and the prestigious National Science Foundation CAREER Award in 2012. He is an Associate Editor for the IEEE Transactions on Industry Applications and IEEE Transactions on Electromagnetic Compatibility. He was a Technical Program Co-Chair for the IEEE 2014 International Electric Vehicle Conference.



### **Yan Wang**

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Dr. Yan Wang is an Assistant Professor in the Department of Urban and Regional Planning. Dr. Wang's research concerns resilient, smart, and safe cities. She studies the resilience of humans and the built environment to natural hazards and public health crises. She also develops data-driven intelligent system to enable agility in disaster and emergency response, and to detect small-scale crises for urban safety. Her research also engages evidence-based planning for urban resilience and data-informed infrastructure planning for future cities. Dr. Wang's expertise includes multimodal data analytics (including natural language processing and computer vision), complex network analysis, spatiotemporal analyses, and real-time geo-visualization.



### **Xiaochen Xian**

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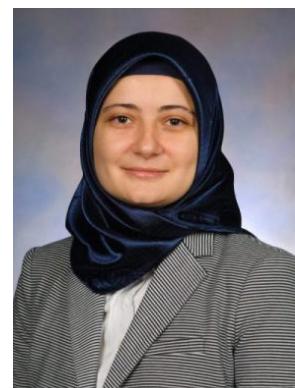
Dr. Xiaochen Xian serves as an Assistant Professor in the UF ISE department. Her research interest mainly focuses on big data analytics and system informatics to develop data-driven methodologies for computationally aware systems. Specifically, her research includes big data stream monitoring and sampling, engineering knowledge-enhanced complex process modeling and diagnosis, on-demand machine learning, and system informatics and spatiotemporal real-time prediction. Her research leads to immediate applications in manufacturing, healthcare, environmental monitoring, smart buildings, and traffic, etc. Dr. Xian received her B.S. from the Department of Mathematics, Zhejiang University, Hangzhou, China, in 2014, and her M.S. in Statistics and Ph.D. in Industrial Engineering from the University of Wisconsin-Madison in 2017 and 2019. She is a member of INFORMS, IISE, and IEEE.



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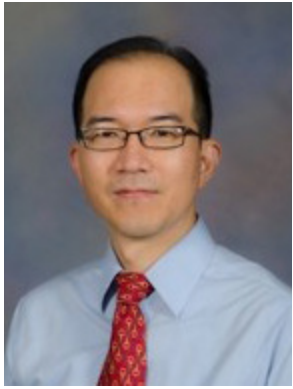
Dr. Wanli Xing is an Associate Professor in the School of Teaching and Learning. Dr. Xing's research focuses on how emerging technologies can deeply transform STEM education and online learning. He creates learning environments using cutting-edge technologies, such as computer simulations and modeling, artificial intelligence, internet of things, and augmented reality to support learning in diverse classrooms and online environments. He also designs and applies data mining and machine learning to understand, assess, and optimize the learning process and the environments in which it occurs. His school-based research projects have produced new theories, principles, and methods on how to design effective educational technology that teaches the knowledge and skills for the future STEM workforce.



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Dr. Tuba Yavuz is an Associate Professor in the Electrical and Computer Engineering Department. Her research is in the intersection of formal methods, software engineering, and system security. She received an NSF CAREER Award in 2020. The overarching goal of her research group, System Reliability Lab (SysRel), is to develop scalable and automated model extraction techniques for improving the reliability and security of the Internet of Things ecosystem. Before joining the ECE Department, Dr. Yavuz worked as a Research Scientist at the Computer and Information Sciences and Engineering (CISE) Department at UF between 2004 and 2014. She received the College of Engineering Teacher of the Year award in 2014. She received her Ph.D. in computer science from the Computer Science Department of University of California, Santa Barbara in 2004.



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Dr. Yong-Kyu “YK” Yoon is a Professor and the Graduate Coordinator in the Department of Electrical and Computer Engineering at the University of Florida. His current research interests include MEMS and nanotechnology, RF/Microwave, millimeter wave and terahertz system, micro/nano-biomedical devices and bio molecule (drug/vaccine/gene) delivery, wireless/wired sensors and actuators, and metamaterial and its RF application. He received his Ph.D. in Electrical and Computer Engineering from Georgia Institute of Technology in 2004.



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