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Warren B. Nelms Institute

for the Connected World

RESEARCH PORTFOLIO 2021

GAINESVILLE, FL
HTTP://IOT.INSTITUTE.UFL.EDU

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About Nelms Institute Research

The Warren B. Nelms Institute 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, we are developing broad Internet of Things (IoT) technologies and applications to create more secure, efficient, and connected communities.

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 Nelms Institute research projects. Many of these projects are collaborative, interdisciplinary, and showcase our unique expertise in IoT.

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- Reactive Swarm Control for Dynamic Environments
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- Artificial neural networks meet biological neural networks: designing personalized stimulation for the data-driven control of neural dynamics

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- DeepTrust: Building Competency-aware AI Systems with Human Centric Communication
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- Trusted and Assured Hardware for IoT
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- Decentralized Detection of Cyber Attacks against Microgrid Energy
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- Investigation of EM Attack and Prevention for Touchscreen Enabled Electronics
- A Risk-Aware DER Management Framework with Real-time DER Trustworthiness Evaluation
- Collaborative Research: SHF: Small: Decentralized Edge Computing Platform for Privacy-Preserving Mobile Crowdsensing (NSF)
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- Collaborative Research: FMitF: Track I: Property-specific Hardware-oriented Formal Verification Modules for Embedded Systems
- Pre-silicon Electromagnetic Side Channel Analysis
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IOT APPLICATIONS

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- SCH: INT: Collaborative Research: Crowd in Action: Human-Centric Privacy-Preserving Data Analytics for Environmental Public Health (NSF)
- VCA-DNN: Neuroscience-Inspired Artificial Intelligence for Visual Emotion Recognition
- Web-based Automated Imaging Differentiation of Parkinsonism
- Modeling Multi-Level Connectivity of Brain Dynamics
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TA4: Public Health (continued)

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- EM Radiation Suppression and Attacking Mitigation with Optimal Layout and Shielding Techniques
- EM Spectrum Prediction and Measurement based on Time Domain Waveforms
- Novel High Power Density and High-Performance Power Semiconductor Packaging Techniques
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- Linking deforestation, urbanization, and agricultural expansion for land use decisions in Ghana
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- CPS: Medium: Collaborative Research: Robust and Intelligent Optimization of Controlled-environment Agriculture System for Food Productivity and Nutritional Security
- Landscapes in flux: the influence of demographic change and institutional mechanisms on land cover change, climate adaptability and food security in rural India
- DARLING – Drone-Based Administration of Remotely Located Instruments and Gears

TA7: Education

- Codebreakers: Cultivating Elementary Students' Interest in Cryptography and Cybersecurity Education and Careers
- To Enact, To Tell, To Write: A Bridge to Expressive Writing through Digital Enactment

TA8: Neuro-engineering

- Neural Storage: A New Paradigm of Elastic Memory
- VCA-DNN: Neuroscience-Inspired Artificial Intelligence for Visual Emotion Recognition
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- Linking deforestation, urbanization, and agricultural expansion for land use decisions in Ghana
- DARLING – Drone-Based Administration of Remotely Located Instruments and Gears

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- Digital Twin Technology to Ensure Food Safety
- CPS: Medium: Collaborative Research: Robust and Intelligent Optimization of Controlled-environment Agriculture System for Food Productivity and Nutritional Security
- Landscapes in flux: the influence of demographic change and institutional mechanisms on land cover change, climate adaptability and food security in rural India

TA11: Consumer Electronics

- A Smart Mask for Active Defense Against Coronaviruses and Other Airborne Pathogens
- RI: Small: Collaborative Research: Dynamic Light Transport Acquisition and Applications to Computational Illumination

TA12: Smart Energy

- Energy Efficiency Improvement for Wireless Power Transfer / charging
- Power Grid Harmonic Reduction for Cascaded Multi-level Power Inverters
- Radiated EMI Reduction and Transformer Design for ACF Power Adapters to Reduce Cost and Size

Research Project Titles

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Research Project Descriptions

P1 Development and validation of micronutrient sensor for fortified food

Investigator: Juan Andrade
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Micronutrient deficiencies continue to afflict populations living in low- and middle-income countries. Though other strategies to address it exist, food fortification is the most cost-effective strategy to improve micronutrient status among vulnerable populations. Despite its effectiveness, the food industry as well as local governments lack tools to monitor fortified food entering the different markets. This is partially due to the limited availability of affordable and valid sensors to support these efforts. Our work focuses on expanding the use of colorimetric sensors to detect micronutrients in fortified foods such as wheat and corn flours. Our paper-based sensors are inexpensive and are as accurate and reliable as the gold standard method, i.e. atomic emission spectrometry.

P2 Codebreakers: Cultivating Elementary Students' Interest in Cryptography and Cybersecurity Education and Careers

Investigators: Pavlo "Pasha" Antonenko, Amber E Benedict, Swarup Bhunia, Kara Dawson
Nelms Institute Contact: Pasha Antonenko, p.antonenko@coe.ufl.edu, (352) 273-4176

This project introduces a new technology-enhanced STEM education model for engaging upper elementary students in cybersecurity and morphological awareness experiences, and STEM identity development in the new and exciting context of making and breaking secret codes. This project focuses on designing a cryptography-focused curriculum and mobile games for after school programs that work with elementary students. Introduction to IoT security for kids is an important module in this curriculum.

P3 Hardware IP Protection through Provably Secure State-Space Obfuscation

Investigators: Swarup Bhunia, Domenic Forte, Mark Tehranipoor
Nelms Institute Contact: Swarup Bhunia, swarup@ece.ufl.edu, (352) 392-5989

Hardware intellectual property (IP) cores are the most essential part of the system-on-chip (SoC) design flow. IPs are vulnerable to a numerous threat e.g., piracy, cloning, counterfeiting, reverse engineering, Trojan insertion, etc. which makes it difficult for the IP vendors to protect their IPs from unauthorized or malicious usage. We propose a novel, scalable, and considerable overhead methodology to provide effective prevention against IP piracy and reverse engineering by netlist level obfuscation. We transform the underlying finite state machine of the design to insert authentication mechanism and expand the state space, which in general is small and prune to state traversal. Due to the expansion of the state space and insertion of authentication mechanism, it becomes difficult for an attacker to re-use or clone the IP for unauthorized use. Additionally, expanded state space hinders reverse engineering of the IP which essentially makes the design resilient to piracy.

P4 SAIL: Machine Learning Guided Structural Analysis Attack on Hardware Obfuscation

Investigators: Swarup Bhunia
Nelms Institute Contact: Swarup Bhunia, swarup@ece.ufl.edu, (352) 392-5989

Obfuscation is a technique for protecting hardware intellectual property (IP) blocks against reverse engineering, piracy, and malicious modifications. Current obfuscation efforts mainly focus on functional locking of a design to prevent black-box usage. They do not directly address hiding design intent through structural transformations, which is an important objective of obfuscation. We note that current obfuscation techniques incorporate only: (1) local, and (2) predictable changes in circuit topology. In this paper, we present SAIL, a structural attack on obfuscation using machine learning (ML) models that exposes a critical vulnerability of these methods. Through this attack, we demonstrate that the gate-level structure of an obfuscated design can be retrieved in most parts through a systematic set of steps. The proposed attack is applicable to all forms of logic obfuscation, and significantly more powerful than existing attacks, e.g., SAT-based attacks, since it does not require the availability of golden functional responses (e.g., an unlocked IC). Evaluation on benchmark circuits show that we can recover an average of about 84% (up to 95%) transformations introduced by obfuscation. We also show that this attack is scalable, flexible, and versatile.

P5 Handheld iNQR system

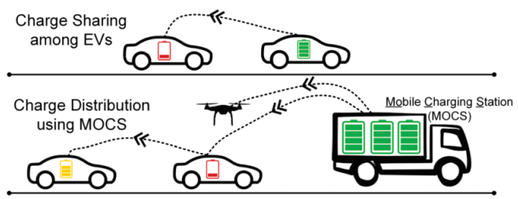
Investigators: Swarup Bhunia, Soumyajit Mandal
Nelms Institute Contact: Swarup Bhunia, swarup@ece.ufl.edu, (352) 392-5989

Consumers and law enforcement are equally concerned about the increase in adulterated consumables that are present in the market. In addition to counterfeited substances, authorities also have to deal with new illegal drugs. These drugs are imported into the country in various ways; often, these substances are available in small quantities and require rapid detection on the field. Previously, we proposed a portable NQR system (known as iNQR) that can be carried onto the field to detect and quantify various chemicals. This system includes all the required components for a portable detection system, including the detector, data accumulator, digital signal processor (DSP), and user interface. However, since this setup can be cumbersome for regular use and challenging to move quickly in the field, here we propose a new portable version of the iNQR system within a hand-held form factor.

P6 P2C2: Peer-to-Peer Car Charging

Investigators: Tamzidul Hoque, Swarup Bhunia
Nelms Institute Contact: Swarup Bhunia, swarup@ece.ufl.edu, (352) 392-5989

With rising concerns over fossil fuel depletion and the impact of Internal Combustion Engine (ICE) vehicles on our climate, the transportation industry is observing a rapid proliferation of Electric Vehicles (EVs). Yet, people continue to use ICE vehicles over EVs due to consumer worries over issues such as limited range, limited battery life, long charging times, and the lack of EV charging stations. Existing solutions to these problems, such as building more charging stations, increasing battery capacity, and road-charging have not been proven efficient so far. In this paper, we propose Peer-to-Peer Car Charging (P2C2), a highly scalable novel technique for charging EVs on-the-go with minimal cost overhead. We allow EVs to share charge among each other based on the instructions from a cloud-based control system. The control system assigns and guides EVs for charge sharing. We also introduce Mobile Charging Stations (MoCS), which are high battery capacity vehicles that are used to replenish the overall charge in the vehicle networks. We have implemented P2C2 and integrated it with the traffic simulator, SUMO. We observe promising results with up to 65% reduction in the number of EV halts and with up to 24.4% reduction in required battery capacity without any extra halts.



P2C2 enabled charge sharing among EVs and MoCS-based charge distribution for charging on the go.

P7 Material Biometrics: NQR Sensitive Embedded Signatures for Authenticating Additively Manufactured Objects

Investigators: Swarup Bhunia, Soumyajit Mandal
Nelms Institute Contact: Swarup Bhunia, swarup@ece.ufl.edu, (352) 392-5989

Automatic recognition of unique characteristics of an object can provide a powerful solution to verify its authenticity and safety. It can mitigate the growth of one of the largest underground industries - that of counterfeit goods - flowing through the global supply chain. In this article, we propose the novel concept of material biometrics, in which the intrinsic chemical properties of structural materials are used to generate unique identifiers for authenticating individual products. For this purpose, the objects to be protected are modified via programmable additive manufacturing of built-in chemical “tags” that generate signatures depending on their chemical composition, quantity, and location. We report a material biometrics-enabled manufacturing flow in which plastic objects are protected using spatially-distributed tags that are optically invisible and difficult to clone. The resulting multi-bit signatures have high entropy and can be non-invasively detected for product authentication using 35Cl nuclear quadrupole resonance (NQR) spectroscopy.

P8 Neural Storage: A New Paradigm of Elastic Memory

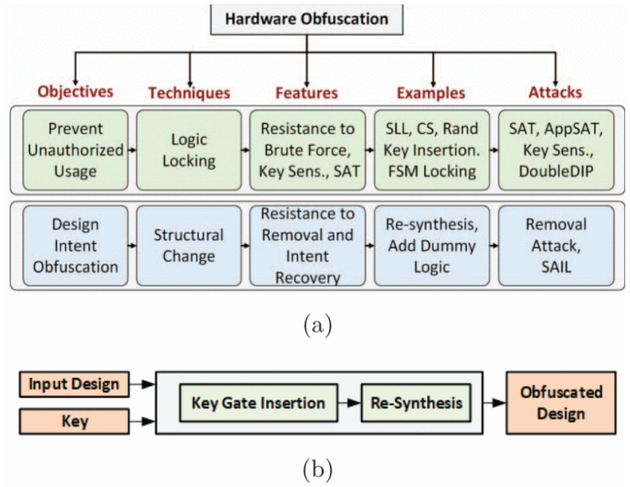
Investigators: Swarup Bhunia
Nelms Institute Contact: Swarup Bhunia, swarup@ece.ufl.edu, (352) 392-5989

Storage and retrieval of data in a computer memory plays a major role in system performance. Traditionally, computer memory organization is static - i.e., they do not change based on the application-specific characteristics in memory access behavior during system operation. Specifically, the association of a data block with a search pattern (or cues) as well as the granularity of a stored data do not evolve. Such a static nature of computer memory, we observe, not only limits the amount of data we can store in a given physical storage, but it also misses the opportunity for dramatic performance improvement in various applications. On the contrary, human memory is characterized by seemingly infinite plasticity in storing and retrieving data - as well as dynamically creating/updating the associations between data and corresponding cues. In this paper, we introduce Neural Storage (NS), a brain-inspired learning memory paradigm that organizes the memory as a flexible neural memory network. In NS, the network structure, strength of associations, and granularity of the data adjust continuously during system operation, providing unprecedented plasticity and performance benefits. We present the associated storage/retrieval/retention algorithms in NS, which integrate a formalized learning process. Using a full-blown operational model, we demonstrate that NS achieves an order of magnitude improvement in memory access performance for two representative applications when compared to traditional content-based memory.

P9 SURF: Joint structural functional attack on logic locking

Investigators: Swarup Bhunia
Nelms Institute Contact: Swarup Bhunia, swarup@ece.ufl.edu, (352) 392-5989

To help protect hardware Intellectual Property (IP) blocks against piracy and reverse engineering, researchers have proposed various obfuscation techniques that aim at hiding design intent and making black-box usage difficult. A dominant form of obfuscation, referred to as logic locking, relies on the insertion of key gates (e.g., XOR/XNOR) at strategic locations in a design followed by logic synthesis. Recently, it has been shown that such an approach leaves predictable structural signatures, which make them susceptible to machine learning (ML) based structural attacks. These attacks are shown to deobfuscate a design by learning the deterministic nature of transformations incorporated by commercial synthesis tools. They are attractive for unraveling the design intent. However, they may not be able to provide a working design. In this paper, we introduce a novel attack on obfuscation techniques, called Structural Functional (SURF) attack, which, for the first time to our knowledge, accomplishes key extraction through scalable functional analysis while leveraging the output of structural attacks. We have developed complete flow and an automatic tool for the attack, which shows promising results. We are able to retrieve, on average, ~90% keybits for obfuscated ISCAS-85 benchmarks (100% in several cases) with > 98% output accuracy. We observe that SURF attack, unlike any known attack, can enable both discovering design intent as well as black-box usage. It is effective for all major variants of logic locking; scalable to large designs; and unlike SAT based attacks, is effective for all design types (e.g., multipliers, where SAT based attacks typically fail).



(a) Overview of hardware obfuscation objective and techniques.
(b) Obfuscation process.

P10 MAGIC: Machine-Learning-Guided Image Compression for Vision Applications in Internet of Things

Investigators: Swarup Bhunia
Nelms Institute Contact: Swarup Bhunia, swarup@ece.ufl.edu, (352) 392-5989

The emergent ecosystems of intelligent edge devices in diverse Internet-of-Things (IoT) applications, from automatic surveillance to precision agriculture, increasingly rely on recording and processing a variety of image data. Due to resource constraints, e.g., energy and communication bandwidth requirements, these applications require compressing the recorded images before transmission. For these applications, image compression commonly requires: 1) maintaining features for coarse-grain pattern recognition instead of the high-level details for human perception due to machine-to-machine communications; 2) high compression ratio that leads to improved energy and transmission efficiency; and 3) large dynamic range of compression and an easy tradeoff between compression factor and quality of reconstruction to accommodate a wide diversity of IoT applications as well as their time-varying energy/performance needs. To address these requirements, we propose, MAGIC, a novel machine learning (ML)-guided image compression framework that judiciously sacrifices the visual quality to achieve much higher compression when compared to traditional techniques, while maintaining accuracy for coarse-grained vision tasks. The central idea is to capture application-specific domain knowledge and efficiently utilize it in achieving high compression. We demonstrate that the MAGIC framework is configurable across a wide range of compression/quality and is capable of compressing beyond the standard quality factor limits of both JPEG 2000 and WebP. We perform experiments on representative IoT applications using two vision data sets and show 42.65× compression at similar accuracy with respect to the source. We highlight low variance in compression rate across images using our technique as compared to JPEG 2000 and WebP.

P11 Trusted and Assured Hardware for IoT

Investigators: Swarup Bhunia, Sandip Ray
Nelms Institute Contact: Swarup Bhunia, swarup@ece.ufl.edu, (352) 392-5989

Dr. Swarup Bhunia and his team are developing standalone Computer-Aided Design (CAD) tools for evaluating trust and assurance for Internet-of-Things (IoT) hardware at all levels. These tools include custom data-structures and algorithms for scalable and efficient processing of large designs at different levels of abstraction, metrics for informative and comprehensive understanding of hardware trust and assurance as well as vulnerabilities, and red and blue dynamic benchmarking for robust data analytics and evaluation on several state-of-the-art attacks and defenses.

P12 PCB-Level Trojan Insertion System

Investigators: Swarup Bhunia, Soumyajit Mandal
Nelms Institute Contact: Swarup Bhunia, swarup@ece.ufl.edu, (352) 392-5989

In this project, Dr. Swarup Bhunia and his team are developing a comprehensive platform encompassing both software and hardware regime for PCB Trojan benchmarking to effectively evaluate emerging solutions for PCB assurance in an untrusted supply chain. The CAD tool uses Trojan templates to automatically find suitable locations within any input PCB design through functional/structural analysis for Trojan insertion. This software suite is expected to include a large representative dataset on the possible attack space of synthetic PCB Trojan benchmarks for commercial PCB designs. Such a framework enables an unbiased and comparable evaluation of various countermeasures. Additionally, Dr. Bhunia's team is developing a flexible and scalable PCB-level emulation system to insert and activate hardware Trojans in modern intricate computing devices.

P13 Memory in Logic PUF

Investigators: Swarup Bhunia
Nelms Institute Contact: Swarup Bhunia, swarup@ece.ufl.edu, (352) 392-5989

Physical Unclonable Functions (PUFs) are a security primitive used for securing, identifying, and authenticating a device. However, current PUF designs on FPGAs can be challenging to implement or incur significant overhead. This often limits their implementation into System on Chip (SoC) designs or other FPGA applications. As such, we propose the Memory in Logic PUF (MeLPUF) a low overhead, distributable PUF which that leverages the existing logic gates which make up the reconfigurable architecture in an FPGA. These on-demand memory cells can be dispersed across the combinational logics of various intellectual property (IP) blocks in an SoC design to achieve distributed authentication. They can also be synthesized with a logic synthesis tool to incorporate and meet the power and area restrictions of a design.

P14 A Smart Mask for Active Defense Against Coronaviruses and Other Airborne Pathogens

Investigators: Soumyajit Mandal, Swarup Bhunia
Nelms Institute Contact: Swarup Bhunia, swarup@ece.ufl.edu, (352) 392-5989

Face masks provide effective, easy-to-use, and low-cost protection against airborne pathogens or infectious agents, including SARS-CoV-2. Existing masks are all passive in nature, i.e., simply act as air filters for the nasal passage and/or mouth. This article presents a new "active mask" paradigm, in which the wearable device is equipped with smart sensors and actuators to both detect the presence of airborne pathogens in real time and take appropriate action to mitigate the threat. The proposed approach is based on a closed-loop control system that senses airborne particles of different sizes near the mask and then makes intelligent decisions to reduce their concentrations. In the current implementation, an on-board controller determines ambient air quality via a commercial particulate matter sensor, and if necessary, activates a piezoelectric actuator that generates a mist spray to load these particles, thus causing them to fall to the ground. The system communicates with the user via a smart phone application that provides various alerts, including the need to recharge and/or decontaminate the mask prior to reuse. The application also enables a user to override the on-board control system and manually control the mist generator if necessary. Experimental results from a functional prototype demonstrate significant reduction in airborne PM counts near the mask when the active protection system is enabled.

P15 Hardware Aware Software Timing Attack Evaluation (HASTE)

Investigators: Swarup Bhunia
Nelms Institute Contact: Swarup Bhunia, swarup@ece.ufl.edu, (352) 392-5989

Dr. Swarup Bhunia and his team are developing an automated framework for the assessment of timing side-channel leakage for a given software running on a given microarchitecture. This work aims to leverage knowledge of the underlying hardware microarchitecture along with software analysis to identify regions of code that are vulnerable to timing side channels.

P16 SAINT – Self-Aware Infrastructure with Intelligent Technologies

Investigators: Joel Harley, Sandip Ray, Swarup Bhunia
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This work is about a coordinated monitoring and response to an emergency situation involving a structural complex as a way to supplement traditional emergency response. This technology uses a series of monitoring units, such as environmental sensors, for an anomaly detection scheme which creates a model of the infrastructure's normal behavior that can be compared against a database of threats. In addition to these units, a fleet of response units includes actuator and/or a fleet of first-responder entities which implement a crowd control protocol and hierarchical staged response prescribed by a central control system. This framework incorporates an infrastructure with a brain, a "self-awareness" for an emergency situation, which can house both the central control system and, if available, first-responder entities. Emergency situations include, but are not limited to, fires and criminal activities. The central control system handles the high-level decision making from collecting data to launching first-responder entities in a systematic manner called staged response. In staged response, the central control system will monitor the infrastructure for any suspicious events in and around it. When an event triggers a plurality of sensors, the central control system will launch one or more first-responder entities to the scene to confirm the threat. The central control system will coordinate with monitoring, response, and hybrid mobile units to make decisions that mitigate and communicate the threat to the appropriate agencies. These units can also make autonomous decisions in the absence of the CCS based on the concept of self-organizing behavior using device-to-device (D2D) technology. The hybrid mobile unit is equipped with several sensors, including but not limited to sound sensors, cameras, short range radar and LIDAR (Light Detection and Ranging). The sensor and actuator networks will collect data from the environmental sensors and control doors, windows, and other actuators within the infrastructure based on commands from the central control system, respectively. A specific incarnation of this framework will include an array of sensors that collectively monitors diverse situations and provides collective intelligence to respond to these situations appropriately, e.g., closing/opening doors/windows. These autonomous entities will detect safety issues and violations such as fire and criminal activities like active shooter and theft. They will respond according to a set of distributed intelligent algorithms.

P17 DARLING – Drone-Based Administration of Remotely Located Instruments and Gears

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This work is about a framework for assisting remote devices using an Unmanned Aerial Vehicle (UAV). The DARLING architecture has three hardware components: the UAV, a base station which is responsible for housing the UAV, and remote devices which the UAV services. We describe all the parts needed for the base station and the UAVs in order to carry out a smooth, remote maintenance procedure. Whenever it is unsafe for the UAV to land near the remote device, we propose the use of a Detachable Charging Unit (DCU) which has a platform that carries a battery pack and connects to the remote device for charging while the UAV services another device. In this invention, we outline three types of maintenance based on schedule or unexpected issues discovered by AI models in both the base station and the UAVs. Most maintenance are what we call regular maintenance, where standard servicing procedures occur, such as charging and data transfer. DARLING can also anticipate future issues on the base station based on the collected diagnostic information from the remote device via the UAV through predictive maintenance. If the UAV predicts or discovers an issue on the device before performing maintenance, it can perform targeted maintenance on this device. We consider two distinct use cases---a) an IoT device that is in a remote location and b) an IoT device that is in an inconvenient location---and demonstrate the role of DARLING in these scenarios.

P18 Decentralized Detection of Cyber Attacks against Microgrid Energy

Investigator: Zoleikha Biron
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This project aims at developing the scientific foundations and the design methodologies for autonomous detection of cyber-attacks against energy management systems in microgrids. The objectives of this project include: (i) developing a comprehensive study on the security of microgrids; (ii) designing a cooperative and distributed methodology to detect cyber-attacks against different units of the microgrid; and (iii) reducing the number of misdetections due to the inevitable uncertainties in system parameters, volatile renewable generation and customer demand profiles. Microgrids are uniquely different from bulk power systems, structurally and operationally. The uniqueness of microgrids makes it significantly more challenging to detect anomalies under cyber-attacks, using the conventional large-scale power system techniques. In this regard, we introduce a distributed framework to enable autonomous detection of cyber-attacks at the unit level using each unit previous observed knowledge of the surrounding microgrid environment. The autonomous unit detection scheme is enforced with the adaptive threshold algorithm to avoid midsection and reduce false-positive alarms.

P19 CNS Core: Small: A Hardware/Software Infrastructure for Secured Multi-Tenancy in FPGA-Accelerated Cloud and Datacenters

Investigator: Christophe Bobda
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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.

P20 Elements: Cyberinfrastructure Service for IoT-Based Construction Research and Applications

Investigators: Aaron Costin, Janise McNair, Sanjeev Koppal, Idris Jeelami
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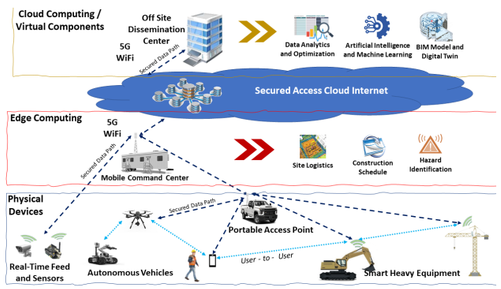
This project develops a robust cyberinfrastructure (CI) system and service for construction research and applications to address the current challenges faced in the construction industry. The outcomes and services that this project aims to provide are 1) a distributed SDN-managed and AI-assisted IoT 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.



P21 To Enact, To Tell, To Write: A Bridge to Expressive Writing through Digital Enactment

Investigator: Sharon Lynn Chu
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Expressive writing is core to the learning of all school subjects. An alarmingly high percentage of students enter middle school with low proficiency in writing, which hinders further learning in high school and college. A key reason for children's difficulties is that writing requires not only proficiency in the technical aspects of language (e.g., grammar, sentence structure), but also the possession of ideas to convey, as well as a mastery of the process of translating ideas into expression. This project investigates an approach that decouples the technical aspects of writing from the imagination aspect, essentially enabling children to focus on one aspect at a time. The approach harnesses the power of full-body and puppet-based pretend play operationalized by low-cost motion-tracking technologies and sensors combined with animation.

P22 Smart Vehicle Platooning Built upon Real-Time Learning and Distributed Optimization

Investigator: Lili Du
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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.

P23 CAREER: Integrated Online Coordinated Routing and Decentralized Control for Connected Vehicle Systems

Investigator: Lili Du
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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.

P24 Smart Bio-Assay Cage Development for Evaluation of Efficacy of Mosquito Control Adulticides

Investigator: William Eisenstadt
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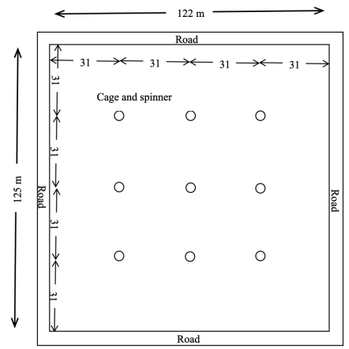
The proposed work will develop a smart sensor and bioassay cage prototypes that will be evaluated in a field environment to demonstrate that the developed products can measure the efficacy of the mosquito adulticide application. This work is unique in that it enables the research collaboration between the entomologists, biologists from Anastasia Mosquito Control District (AMCD) and electronics and sensor experts (University of Florida, Dept of ECE). The work will develop a prototype smart mosquito sensor and bioassay cage that, 1) evaluates the properties of insect spray aerosols, 2) records environmental information at the time of spraying such as temperature, humidity and location, and 3) reports the information wirelessly to a cell phone or a computer. The work will compare the newly developed smart bioassay cage to existing techniques for mosquito cage spray evaluation and build a cross-reference guide.



Field layout of adulticide efficacy trials

P25 SCH: INT: Collaborative Research: Crowd in Action: Human-Centric Privacy-Preserving Data Analytics for Environmental Public Health (NSF)

Investigator: Yuguang "Michael" Fang
Nelms Institute Contact: Michael Fang, fang@ece.ufl.edu, 352-846-3043

This project serves as a training ground for educating future decision-makers and workforce on privacy-preserving healthcare technologies. This multidisciplinary research advances the state-of-the-art public health by combining multi-scale data collection and analysis. Specifically, the project redesigns current healthcare monitoring systems for both severe infectious diseases and long-term environment-related diseases and their exacerbation (e.g., air pollutant-induced pulmonary diseases, such as chronic obstructive pulmonary disease and lung cancer). By considering the high sensitivity and distributed manner of the data from patients and users, this project addresses the privacy preservation in two-fold: 1) completely redesign efficient collaborative classification schemes by applying novel metrics without leaking individual's privacy; and 2) introduce new architectures to perform crowdsourcing data analysis by using light-weighted and verifiable encryption schemes. This project also grounds the theoretical outcomes to actual crowdsensing systems and social networks for validation. Finally, a new methodology on public health prediction model is developed with practical systematic implementation in healthcare systems.

P26 NeTS: Small: Proof-of-Concept Study on an Emerging Mobile Data Transportation Network (NSF)

Investigator: Yuguang "Michael" Fang
Nelms Institute Contact: Michael Fang, fang@ece.ufl.edu, 352-846-3043

This one-year project aims to demonstrate how to leverage light-weight vehicles equipped with powerful cognitive radio (CR) routers with high computational capability and relatively large storage capacity to perform spectrum sensing, processing and storing data, making intelligent decisions, and opportunistically transporting data for emerging IoT systems and smart cities applications. To achieve this goal, the project plans to design a flexible and agile cognitive network architecture to effectively take advantage of the added capability in vehicles. Under this architecture, a suite of spectrum management mechanisms will be developed from both access point of view and end-to-end service perspective. Delay-tolerant traffic will shift to this emerging network where harvested licensed or unlicensed spectrum can be used to opportunistically store-carry-forward data traffic. By designing various kinds of opportunistic data offloading mechanisms, the project seeks to explore the effectiveness of such a data transportation network.

P27 VCA-DNN: Neuroscience-Inspired Artificial Intelligence for Visual Emotion Recognition

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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.

P28 Web-based Automated Imaging Differentiation of Parkinsonism

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

P29 Modeling Multi-Level Connectivity of Brain Dynamics

Investigators: Ruogu Fang, Mingzhou Ding
Nelms Institute Contact: Ruogu Fang, ruogu.fang@bme.ufl.edu, 352-294-1375

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. 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.

P30 Reactive Swarm Control for Dynamic Environments

Investigator: Matthew Hale
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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.

P31 CAREER: A Unified Theory of Private Control Systems

Investigator: Matthew Hale
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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.

P32 CAREER: Fast Foveation: Bringing Active Vision into the Camera

Investigator: Sanjeev Koppal
Nelms Institute Contact: Sanjeev Koppal, sjkoppal@ece.ufl.edu, (352) 392-8942

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.

P33 RI: Small: Collaborative Research: Dynamic Light Transport Acquisition and Applications to Computational Illumination

Investigator: Sanjeev Koppal
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The light-transport matrix is a rich and complex representation of how light from an illumination source interacts with a scene and reaches the camera. Unfortunately, light transport matrices are huge; the light ray set is typically large and, further, the radiance quality along the rays (high dynamic range, color, etc.) implies a big data footprint. In this project, the researchers consider dynamic light-transport matrices for scenes with motion, where the size and throughput requirements are even higher and have inhibited previous work on capture, analysis and applications. They believe that breaking through these imaging challenges is useful because a dataset of dynamic light-transport matrices will allow the team to intricately unwrap complex interactions of light and objects in time, such as motion, occlusion as line-of sight changes, illumination due to lighting variation, secondary light paths such as specular interreflections and indirect/global illumination of dynamic scenes. The full light-transport at each moment in time provides a complete picture of these dynamic interactions (allowing scene recovery by tracking and 3D scanning), with secondary light paths that offer robustness in the face of complex visual effects (allowing post-capture image-based relighting). The goal of this project is to fundamentally understand and characterize the properties of light transport for dynamic, moving objects.

P34 Directionally Controlled Time-of-Flight Sensors: Algorithms, Optical and Imaging Strategies

Investigator: Sanjeev Koppal, Huikai Xie
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We explore the novel imaging capabilities induced by a depth sensor that can control exactly where and when measurement occurs. Such a sensor is freed from the constraint of spatial samples in a fixed array and can, in real-time, adaptively sample the scene to achieve vision for complex scenes. The availability of fast microelectromechanical (MEMS) mirrors and fast computation has converged in the present moment, allowing this research to happen, for the first time, unconstrained by significant hardware limitations. Our testbed uses a MEMS mirror to reflect a single pulsed laser over a field-of-view to obtain 3D scans. The voltages that control the MEMS actuators allow analog (continuous) time-of-flight (TOF sensing angles. As a modulator, MEMS mirrors have well-known advantages of high-speed and fast response to control.

P35 Collaborative Research: SWIFT: LARGE: MAC-on-MAC: A Spectrum Orchestrating Control Plane for Coexisting Wireless Systems

Investigators: Janise McNair, Soumyajit Mandal
Nelms Institute Contact: Janise McNair, mcnair@ece.ufl.edu, (352) 392-2629

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. 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.

P36 Digital Twin Technology to Ensure Food Safety

Investigators: Ziynet Boz, Rafael Muñoz-Carpena, Janise McNair, Michelle Danyluk
Nelms Institute Contact: Janise McNair, mcnair@ece.ufl.edu, (352) 392-2629

This seed project will demonstrate the concept of Digital Twin technology in the cold chain applications of fresh produce. The temperature of the refrigerated case and temperature-related quality of fresh produce will be monitored based on the sensor data and mechanistic models run real time. User interface will provide optimum shelf life decision criteria for the refrigerator (e.g., assets) operation or food handling (e.g., sale incentives, donation, etc. Findings from this project will be extended to enable IoT-based monitoring, tracking and management of system-wide distributed cold chain fresh produce.

P37 Distributed Opportunistic Monitoring of In-Situ Networks

Investigator: Sandip Ray
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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.

P38 Resilient System-on-Chip Architecture

Investigator: Sandip Ray
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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". 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.

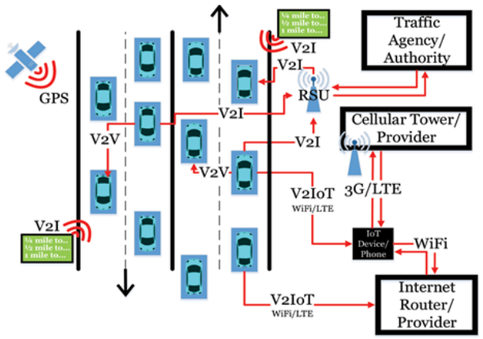
P39 Security Assurance for Autonomous Vehicular Communications

Investigator: Sandip Ray
Nelms Institute Contact: Sandip Ray, sandip@ece.ufl.edu

How would you feel if a hacker could remotely push a button that would cause your vehicle to veer off the highway into a ditch? Research over the last decade has shown that not only is this possible but it is actually depressingly easy for a trained hacker to do so. The reason is that as vehicles get infused with electronics and software to support and create various autonomous features, they are starting to look more like computers than as traditional cars. That also means that they are inheriting the problems that have plagued computers for decades – cyber-security. The only difference in this case is that vehicles are more like computers driving at 70 miles/hour and with people inside. Cyber-attacks on these systems can cause catastrophic accidents, cost human life, and bring down transportation infrastructure. As we increase autonomous features of vehicles and move toward self-driving cars, we are sorely in need for a robust vehicular design that is resilient to cyber-attacks.

A key feature of emergent vehicles is connectivity. Vehicles can "talk" to other vehicles as well as with the transportation infrastructure through sensors and inter-vehicular communications (called V2X) to enable smooth and efficient traffic flow and infrastructure utilization. Connected autonomous vehicle (CAV) applications are designed today include platooning, cooperative collision detection, cooperative on-ramp merging, etc. Connectivity, however, is also one of the most vulnerable components of autonomous vehicles and one of the crucial entry points for cyber-attacks. A key feature of such attacks is that they can be conducted without requiring an adversary to actually hack into the hardware/software or physical components of the target vehicle. They can simply send misleading or even malformed communications to "confuse" the communication or sensor systems.

The goal of this project is o address this crucial problem of cyber-resiliency of CAV applications. A key result from the team is a unique AI-based resiliency architecture against arbitrary cyber-attacks on perception channels (e.g., communication and sensor channels). To our knowledge this is the first (and so far, the only) comprehensive resiliency framework for connected vehicle applications against arbitrary cyber-attacks. The architecture exploits recent advances in AI and machine learning to create a unique, on-board predictor to detect, identify, and respond to malicious communications and sensory subversions. A unique feature of the approach is that it can provide assured resiliency against a large class of adversaries, including unknown attacks. We have instantiated the approach on several CAV applications and developed an extensive experimental evaluation methodology for demonstrating such resiliency.



Vehicular communication, also known as V2X, with traditional, connected, and autonomous vehicles. Each line corresponds to a type of one- or two-way communication channel for a specific application (V2V, V2I, and V2IoT). Each connectivity line may also represent a potential attack vector for an exploitation.

P40 Post-silicon Validation

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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.

P41 Automatically Validating SoC Firmware through Machine Learning and Concolic Testing

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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, ARM™, 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.

P42 Artificial neural networks meet biological neural networks: designing personalized stimulation for the data-driven control of neural dynamics

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Personalized neurostimulation using data-driven models has enormous potential to restore neural activity towards health. However, the inference of individualized high- dimensional dynamical models from data remains challenging due to their under-constrained nature. Moreover, the design of stimulation strategies requires exploration of extremely large parameter spaces. To address these issues, we will leverage the wealth of data that multi-subject experiments provide, as well as the computational resources newly available at UF. We will develop new AI methods that utilize in-vivo neural responses to design and implement personalized stimulation in real-time. These will be developed using functional Magnetic Resonance Imaging (fMRI) datasets collected in-house to examine neural activity related to memory / cognition. We will (Aim 1) build recurrent neural networks of memory-related neural activity, and (Aim 2) design personalized brain stimulation to achieve a memory-enhanced neural response. Promising stimulation strategies will be validated in- silico on multiple datasets and finally in-vivo using an fMRI-compatible neural probe.

P43 Linking deforestation, urbanization, and agricultural expansion for land use decisions in Ghana

Investigators: Jasmeet Judge, Aditya Singh, Olivier Walther, Changjie Chen, Foster Mensah, Gregory Kiker, Rachata Muneepeerakul, Kwadwo Owusu
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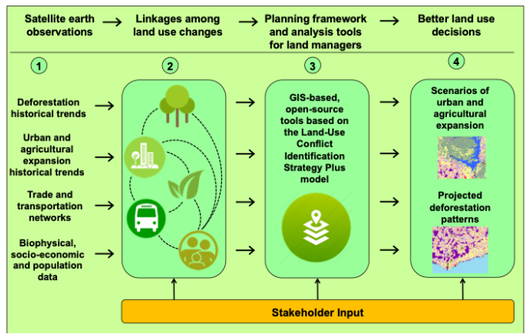
Assists local and regional land management agencies in Ghana resolve land management conflicts by using remote sensing products integrated into a geographical information systems-based land use planning management information system.



P44 NSF: Disentangling cross-scale influences on tree species, traits, and diversity from individual trees to continental scales

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

P45 CPS: Medium: Collaborative Research: Robust and Intelligent Optimization of Controlled-environment Agriculture System for Food Productivity and Nutritional Security

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Operation control optimization and automation for growing nutrient rich produce from recycled graywater in containerized hydroponic systems.

P46 Landscapes in flux: the influence of demographic change and institutional mechanisms on land cover change, climate adaptability and food security in rural India

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This project combines household-scale surveys and regional-scale socioeconomic data with remote sensing imagery to assess the causes and consequences of land cover change and food insecurity in India.

P47 SHF: Small: Enabling New Machine-Learning Usage Scenarios with Software-Defined Hardware for Symbolic Regression

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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.

Despite being studied for decades, symbolic regression is generally limited to toy examples due to the challenge of searching an infinite solution space with numerous local optima. This project presents a solution that significantly advances the state-of-the-art via two primary contributions: 1) 1,000,000x acceleration of the symbolic-regression exploration process, and 2) fundamentally new exploration algorithms that are only possible with such significant acceleration. To accelerate the symbolic-regression exploration process, the investigators introduce software-defined hardware that re-configures every cycle to provide a solution-specific pipeline implemented as a virtual hardware overlay on field-programmable gate arrays. Although this acceleration by itself improves upon the state-of-the-art in symbolic regression considerably, the more important contribution is the enabling of new exploration algorithms that are not feasible without massive increases in performance. The investigators use this performance improvement to introduce a new hybrid exploration algorithm that performs multiple concurrent searches using different configurations of genetic programming and deterministic heuristics, combined with two new prediction mechanisms to avoid local optima: sub-tree look-ahead prediction and operator correlation.

P48 Stress-Mediated Sc-Doped AlN Ferroelectric Transducer for Intrinsically Configurable Solidly Mounted Filter Array

Investigators: Roozbeh Tabrizian, Toshikazu Nishida
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The objective of this project is to develop “Stress-Mediated Sc-Doped AlN Ferroelectric Transducer” for “Intrinsically Configurable Solidly Mounted Filter Array.” The proposed technology relies on tailoring of ferroelectric properties in ScxAl1-xN (30% < x < 45%) through layering with ultra-thin transition-metal nitride films and engineering of the film through mechanical stress. Our unique approach targets creation of stress-mediated ScxAl1-xN transducer stack through successive layering with ultra-thin transition-metal nitrides to enhance residual stress and enable device-level mechanical stress tailoring through in-situ ovenization.

P49 CAREER: Active Nano-Acoustic Waveguide Matrix to Tackle Signal Processing Limits: Enabling Wideband and Nonrecipricol Integrated Communication Beyond the UHF

Investigators: Roozbeh Tabrizian
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To accommodate the explosive demand for wireless communication capacity, this research will enable efficient use of underexploited cm- and mm-wave spectrums (3-300 GHz) by developing transformative integrated acoustic signal processing devices and systems. Research shall consist of (1) investigation of nano-acoustic waveguides in semiconductors, with a focus on single crystal germanium, for wideband signal processing beyond the ultra-high-frequency regime (>UHF: 0.3-3GHz); (2) exploration of the physics/science of active electronic amplification of elastic signals through the acoustoelectric effect in piezoelectric-semiconductor nano-acoustic waveguides; (3) design and demonstration of low-loss and wideband signal processors beyond the UHF; and (4) engineering of chip-scale nonreciprocal signal processors, with a focus on isolators and circulators. The integrated research and education plan involves creation of the first educational Nano-kit, development of the Nano-Workshop and course materials, and outreach activities dedicated to the nano-acoustic signal processing.

P50 Ferroelectrically Transduced Ge Nano-Fin Bulk Acoustic Resonators for Chip-Scale Instinctually Adaptive RF Spectral Processing

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The proposed technology relies on the novel ferroelectrically transduced nano-Fin Bulk Acoustic Resonators (Nano-FinBAR) that enable realization and monolithic integration of instinctual frequency selective limiters (FSL) and bandpass filter arrays to cover the entire X-band (i.e. 8-12 GHz). This technology will transform tactical communication systems through radical miniaturization of size, weight, and power consumption (SWaP) of their RF front-end module, and instinctual and instantaneous immunization of their operation to RF interference. Currently, such a technology does not exist, and interference-management / jamming-protection is achieved through software-based techniques using machine learning strategies and computing resources. This approach significantly adds to the complexity and power consumption of the system and imposes tremendous latency in transceiver operation.

P51 When Adversarial Learning Meets Differential Privacy: Theoretical Foundation and Applications

Investigators: Hai Phan, My T. Thai
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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. 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.

P52 Multi-Layer and Systematic Analytics for Securing the Internet-of-Things

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By breaking a typical IoT system into application and Internet layers, we aim to build a set of monitoring, analysis, and defense capabilities that run in parallel to the IoT applications to a) perform various security analyses within a given system layer, b) use cross-layer artifacts towards detecting high-level security events. The transformative aspect of our work is the investigation of residual application- and network-layer artifacts written in applications to characterize in-depth application- and network level behaviors. Not only this will lead to amplified performance efficiencies, but also address unique and intrinsic features of IoT software that will most likely withstand software evolution.

P53 DeepTrust: Building Competency-aware AI Systems with Human Centric Communication

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This project aims to develop a machine learning (ML) system that combats visual misinformation such as fake/altered photos in a news context through trust-building machine-human interactions. Specifically, the project will focus on building human trust of the news diagnostics from the machine learning system through reported competency-based self-assessment and human centric explanations of the visual diagnostics. The research methods will entail: 1) an adaptive ML system that can self-assess the performance level of any classifier, with a provable guarantee, 2) an explainer that is robust to adversarial attacks and in a human-understandable, trusted form, and 3) method to assess best human-machine communication approaches in news consumption and the communication preferences of news consumers for such explainers.

P54 FAI: Towards a Computational Foundation for Fair Network Learning

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

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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. 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. This project takes a shift for network learning, from answering who and what to answering how and why. It develops computational theories, algorithms and prototype systems in the context of network learning, forming three key pillars (interpretation, auditing, de-biasing) of fair network learning.

P55 Stream-Based Active Mining at Scale: Non-Linear Non-Submodular Maximization

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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. This project develops a theoretical framework together with highly scalable approximation algorithms and tight theoretical performance bound guarantees for the class of non-submodular and non-linear optimization. In particular, the project lays the foundation for the novel data mining techniques, suitable to the new era of big data with emerging applications, as well as advance the research front of stochastic and stream-based algorithm designs.

P56 Lightweight Adaptive Algorithms for Network Optimization at Scale towards Emerging Services

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The era of cloud computing transformed how information is delivered. With devices becoming “smarter” and “plugged” into the Internet, we are entering into a new era of “Internet of Things” (IoT) and cyber-physical systems. These requirements call for scalable and intelligent network algorithms for controlling and coordinating various network components and managing and optimizing resource allocations. This project puts forth a three-plane view of networking as a conceptual framework to structure network functions and guide us in the network algorithmic designs for timely, resilient and resource-efficient information delivery: 1) an information plane capturing application semantics and requirements; 2) a (logically) centralized control plane; and 3) a distributed (programmable) communication (data) plane. This project postulates two design principles and challenges in network algorithms: a) the need for co-design of centralized and distributed network algorithms and b) the need for just-in-time (near) optimality.

P57 EM Spectrum Prediction and Measurement based on Time Domain Waveforms

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Time-domain EM radiation can be measured using EM probes and an oscilloscope. The measured EM signal can be analyzed for getting useful information. On the other hand, the EM signals have their special spectrum signatures. By analyzing the relationship of time-domain EMI signal and frequency domain spectrum, one can predict the EM spectrum and decipher useful information from the spectrum which is impossible from the analysis of time-domain signals.

P58 Radiated EMI Reduction and Transformer Design for ACF Power Adapters to Reduce Cost and Size

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Flyback converter topology has been a popular topology for the AC/DC power adapters of portable electronics such as smartphones, tablets and Chromebooks because it is low cost and requires small number of components. The Flyback transformer should be investigated to reduce EMI, increase energy efficiency and reduce leakage inductance, with a focus on the winding optimization to improve both energy efficiency, reduce conductive & radiated EMI and reduce leakage inductance for parasitic ring reduction.

P59 Novel High Power Density and High-Performance Power Semiconductor Packaging Techniques

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Modern power electronics demand high power density and high-performance power semiconductor devices. The packaging techniques play a big role in the power semiconductor's performance. It is found that not only self but also mutual parasitic inductance in the packaging layout play an important role in semiconductor's switching and EM radiation behavior. A novel packaging technique is being developed to drastically reduce the parasitics and therefore reduce parasitic voltage ringings, reduce switching power loss, reduce thermal stress, reduce EM radiation and improve the reliability and power density of the semiconductor devices.

P60 Wide Bandgap Device EM Characterization and Performance Improvement Novel EM Radiation Suppression Techniques

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Due to their high switching speed, SiC and GaN wide-bandgap devices are more and more popular in high-frequency energy conversion systems. However, high speed leads to high radiated near field and far-field EM radiation. The EM radiation can contaminate the digital and control circuits nearby causing safety and reliability issues. The relationship between the switching characteristics and EM radiation is being investigated and the EM model is being developed. Based on the model, EM radiation can be predicted and novel suppression techniques are being developed.

P61 EM Radiation of Modern High-Speed Variable Motor Drive Systems

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Modern high-speed variable motor drive systems are widely used in the electrification of transportation systems. These systems include both small-signal and high power systems. The high power system generates EM radiation which can induce unwanted noise in the small-signal systems. The noise can lead to system malfunction causing safety and reliability issues. Identifying the EMI radiation sources, understanding the radiation mechanism, and developing suppression techniques are extremely important in the applications of electrification of transportation.

P62 Automotive Power Converter EM Radiation Characterization and Suppression

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DC/DC power conversion is very popular in automotive applications. Some of the examples are the drivers of LED lighting and the auxiliary power supplies for the digital signal processing (DSP) control unit. The EM radiation can be generated from inappropriate PCB layouts, commercial magnetic components, undesired cable antennas, and unwanted near-field couplings. Investigating the mechanism of the EM radiation and optimizing PCB layout and magnetic component design can greatly reduce the radiated EM interference.

P63 EM Radiation Suppression and Attacking Mitigation with Optimal Layout and Shielding Techniques

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EM radiation from electronics circuits such as IC and power converters is troublesome. Attackers can use EM side-channel leakage techniques to procure the information of the ICs and energy conversion systems to launch possible malicious attacks. The EM radiation is related to the internal power delivery layouts of ICs and outer PCB layouts. By understanding the EM radiation generated by the layouts, one can minimize the EM radiation, mitigate the risk of EM side-channel leakage-related attack, and improve the safety of the systems. Optimal shielding techniques can also be implemented to both IC packaging level and circuit structure level to minimize the risk of EM side-channel attacks

P64 Magnetic Field Emission and Reduction for Magnetic Components

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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.

P65 Energy Efficiency Improvement for Wireless Power Transfer / charging

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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.

P66 Power Grid Harmonic Reduction for Cascaded Multilevel Power Inverters

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Grid-tied power inverters generate harmonics to the power grid which reduces the power quality. Reducing the harmonics generated by the power inverters with an optimal modulation control scheme, optimal component parameter design, and novel harmonic reduction algorithm can significantly improve the power inverter's compatibility and power grid's power quality.

P67 Investigation of EM Attack and Prevention for Touch-screen Enabled Electronics

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Touchscreens have been very popular in both consumer and commercial electronics since the last decade. The operation of the touchscreen is based on the sensed electric charge change. Hackers can attack the touch screen and control the Apps by performing EM attacks wirelessly. By exploring the operation of touchscreen, developing EM attack theory, and quantifying the attacking electric field strength, a touchscreen EM attack technique is discovered, demonstrated, and quantified. Corresponding prevention techniques are also proposed.

P68 Intel SHIP Project

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Transforming gate-level circuit designs into hypergraphs allow for more efficient analysis and sub-division. Specifically partitioning hypergraphs into several small subgraph reduces work load 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.

P69 AI Enhanced Side Channel Analysis

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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.

P70 Pre-silicon Electromagnetic Side Channel Analysis

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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-silicone 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.

P71 Hardware Accelerator Side Channel Analysis and Mitigation Techniques

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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.

P72 A Risk-Aware DER Management Framework with Real-time DER Trustworthiness Evaluation

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The increasing penetration level of distributed energy resources (DERs) substantially expands the attack surface of the modern power grid. By compromising DERs, adversaries can destabilize the grid and potentially causing large-area blackouts. Due to the limited administrative control over DERs, constrained computational capabilities, and possible physical accesses to DERs, current device level defenses are insufficient to defend against malicious attacks on DERs. To compensate the shortcomings of device level defenses, in this paper, we develop a system-level risk-aware DER management framework (RADM) to mitigate the attack impacts. We propose a metric, trust score, to dynamically evaluate the trustworthiness of DERs. The trust scores are initialized with offline trust scores derived from static information and then regularly updated with online trust scores derived from a physics-guided Gaussian Process Regressor using real-time data. The trust scores are integrated into the grid control decision making process by balancing the grid performance and the security risks.

P73 Collaborative Research: SHF: Small: Decentralized Edge Computing Platform for Privacy-Preserving Mobile Crowdsensing (NSF)

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Mobile Crowdsensing (MCS) is an important data collection paradigm that leverages natural human mobility and sensing capabilities of smartphones to achieve large spatial-temporal coverage and avoid the cost of deploying fixed sensing infrastructure. Existing works on MCS assume cloud-centric architecture that has three limitations: 1) it aggregates sensor data from all users to a centralized cloud server through a long path in the back-haul Internet network, which raises high data security concerns; 2) it localizes the collected sensor data by tracking the real-time location of each participant, which raises serious location privacy concerns; and 3) its response delay from multi-hop-away cloud may be unacceptable to some applications that require fast response of a service request. This project addresses these challenges with a new decentralized design of MCS system with novel message-passing based spatial-temporal sensor data recovery algorithms to make the MCS more secure and responsive.

P74 | Forecasting trajectories of HIV transmission networks with a novel phylodynamic and deep learning framework (NIH)

Investigators: Marco Salemi, Mattia Prosperi, Dapeng Oliver Wu
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Despite the advent of combined antiretroviral therapy, the ongoing HIV epidemic still defies prevention and intervention strategies designed to reduce significantly both prevalence and incidence worldwide. Phylodynamic analysis has extensively been used in the HIV field to track the origin and reconstruct the virus demographic history both at local, regional and global level. However, such studies have been so far only retrospective, with little or no power to make predictions about future epidemic trends. The overarching goal of the project is to develop an innovative computational framework coupling phylodynamic inference and behavioral network data with artificial intelligence algorithms capable of predicting HIV transmission clusters future trajectory, and informing on key determinants of new infections. We will achieve this goal by carrying out three specific aims: 1. Develop a phylodynamic-based PRIDE module to forecast HIV infection hotspots [the infected]; 2. Develop a behavioral network-based PRIDE module for risk of HIV infection [the uninfected], and 3. Carry out focus groups for deploying the new PRIDE forecasting technology into public health, and implement prevention through the peer change agent model.

P75 | SaTC: CORE: Small: FIRMA: Personalized Cross-Layer Continuous Authentication (NSF)

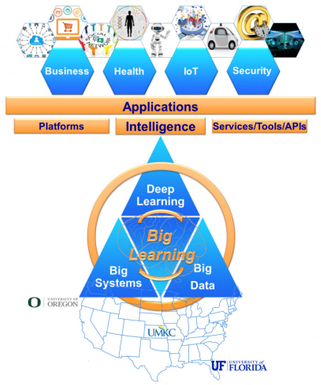
Investigators: Daniela Oliveira, Natalie Ebner, Dapeng Oliver Wu
Nelms Institute Contact: Dapeng Oliver Wu, dpwu@ufl.edu, 352-392-4954

The goal of this project is to build and evaluate FIRMA, a personalized, user-transparent, continuous authentication framework for the Windows OS based on deep learning and the continuous collection of data across the user, operating system, and network layers. This large, heterogeneous, high-dimensional, and temporal data will be used to create a personalized user profile and a deep learning module that will predict at runtime the confidence level of a user identity. This confidence level can be used by a system administrator to determine the level of access a user/employee can have on system resources, and detect stealthy malware and early indications of insider attacks. FIRMA's novel deep learning module will also be able to adapt to benign changes in the user's profile. This project will generate the following outcomes: (i) FIRMA, a personalized, user transparent, continuous authentication framework that can help organizations in identifying employees' identity level, and detecting sophisticated malware and early indications of insider attacks, (ii) a novel deep learning classifier for detecting deviations from a user computer behavioral profile at runtime, (iii) a public, opensource cross-layer computer behavioral profile extractor, and (iv) analysis of real user profiles extracted in a ecologically-valid longitudinal study with 100 participants.

P76 | I/UCRC Center for Big Learning (NSF)

Investigators: Dapeng Oliver Wu, Jose Principe
Nelms Institute Contact: Dapeng Oliver Wu, dpwu@ufl.edu, 352-392-4954

The Mission and Vision of the NSF I/UCRC Center for Big Learning (BigLearning) is to create a multi-site multi-disciplinary center that explores research frontiers in emerging large-scale deep learning and machine learning for a broad spectrum of big data applications, designs novel mobile and cloud services and big data ecosystems to enable big learning research and applications, transfers research discoveries to meet urgent needs in industry with our diverse center members, and nurtures our next generation talents in a mixed forward-looking setting with real-world relevance and significance by the industry-university consortium. The center focuses on emerging large-scale deep learning and machine learning, enabling cloud and big data services, products, and applications in aerospace, ecommerce, unmanned vehicles, precision medicine, mobile intelligence, recommender systems, social robots, surveillance, and ultimate in machine intelligence.



P77 | Collaborative Research: SHF: Medium: Heterogeneous Architecture for Collaborative Machine Learning

Investigators: Dapeng Oliver Wu
Nelms Institute Contact: Dapeng Oliver Wu, dpwu@ufl.edu, 352-392-4954

The recent breakthrough of on-device machine learning with specialized artificial-intelligence hardware brings machine intelligence closer to individual devices. To leverage the power of the crowd, collaborative machine learning makes it possible to build up machine-learning models based on datasets that are distributed across multiple devices while preventing data leakage. However, most existing efforts are focused on homogeneous devices; given the widespread yet heterogeneous participants in practice, it is urgently important but challenging to manage immense heterogeneity. The research team develops heterogeneous architectures for collaborative machine learning to achieve three objectives under heterogeneity: efficiency, adaptivity, and privacy. The proposed heterogeneous architecture for collaborative machine learning is bringing tangible benefits for a wide range of disciplines that employ artificial intelligence technologies, such as healthcare, precision medicine, cyber physical systems, and education. The research findings of this project are intended to be integrated with the existing courses and K-12 programs. Furthermore, the research team is actively engaged in activities that encourage students from underrepresented groups to participate in computer science and engineering research.

P78 CAREER: Towards a Secure and Reliable Internet of Things through Automated Model Extraction and Analysis

Investigator: Tuba Yavuz
Nelms Institute Contact: Tuba Yavuz, tuba@ece.ufl.edu, (352) 846-0202

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. Recent studies on the insecurity of emerging Internet of Things (IoT) has resurfaced 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.

P79 Collaborative Research: FMitF: Track I: Property-specific Hardware-oriented Formal Verification Modules for Embedded Systems

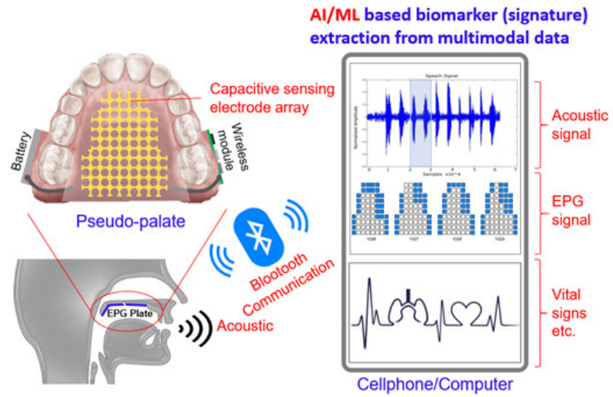
Investigators: Tuba Yavuz, Yier Jin
Nelms Institute Contact: Tuba Yavuz, tuba@ece.ufl.edu, (352) 846-0202

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.

P80 Smart Electropalatography for Linguistic and Medical Applications (SELMA)

Investigators: Yong-Kyu "YK" Yoon, Ratree Wayland, Kevin Tang, Lori Altmann
Nelms Institute Contact: YK Yoon, ykyoon@ece.ufl.edu, (352) 392-5985

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)

Faculty Bios

Swarup Bhunia

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.

My T. Thai

Dr. My T. Thai is the Associate Director of the Warren B. Nelms Institute and a professor in the Department of Computer and Information Sciences and Engineering at the University of Florida. Dr. Thai's current research interests include explainable AI, AI Security and Privacy, and Optimization. The results of her work have led to 7 books and 250+ publications in highly ranked international journals and conferences, including several best paper awards from the IEEE and ACM. Dr. Thai received many recognitions, including UF Research Foundation professorship, IoT Term professorship, NSF CAREER Award, and DTRA Young Investigator Award. She is an IEEE Fellow. Among many professional activities, Dr. Thai currently serves as Editor-in-Chief (EiC) of the Journal of Combinatorial Optimization, and EiC of the IET Blockchain journal.

Juan E. Andrade

Dr. Andrade is an Associate Professor of Global Nutrition in the Department of Food Science and Human Nutrition with a long-term goal to develop sustainable strategies and technologies that can be used to deliver adequate nutrition, especially micronutrients, to residents of low-income countries and thereby help to promote human health and economic development. His research interests are focused on agriculture and food and nutrition security programs, food fortification, low-cost, point-of-use diagnostic tools for assessment, quality of food aid products, and service, experiential learning education programs. Dr. Andrade's current research efforts are focused on the problem of protein and micronutrient malnutrition, development of better vehicles for food fortification, and improvement of RUTF functionality.

Pavlo "Pasha" Antonenko

Pavlo "Pasha" Antonenko is an Associate Professor of Educational Technology and Director of the NeurAL Lab in the School of Teaching and Learning. His research has been funded by state and federal agencies and focuses on developing, implementing, and studying technologies for scaffolding learning. He is the Educational Technology Strand Co-Coordinator for the National Association for Research in Science Teaching, Chair of the American Educational Research Association's Special Interest Group in Instructional Technology, and a reviewer for multiple journals, conferences, and funding agencies.

Zoleikha Biron

Dr. 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.

Christophe Bobda

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. Dr. Bobda received the best dissertation award 2003 from the University of Paderborn for his work on synthesis of reconfigurable systems using temporal partitioning and temporal placement. In 2005 Dr. Bobda was appointed assistant professor at the University of Kaiserslautern. There he set the chair for Self-Organizing Embedded Systems that he led until October 2007.

Sharon Lynn Chu

Sharon Lynn Chu is an Assistant Professor at the University of Florida (UF) 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, the lab studies human behavior in technological contexts. Dr. Chu's research interests include wearables, maker technologies, creativity support systems, positive computing, everyday-inspired media, meaning media, experiential learning, culturally- relevant learning, and STEM education.

Aaron Costin

Dr. Aaron Costin is an assistant 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. Sustainability is a focus of his research. He is investigating 1) how we can utilize IoT technology to increase sustainability applications, and 2) how IoT technology can become more energy efficient.

Lili Du

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. Her research interests include connected and autonomous vehicle systems, Big Data Analytics for transportation systems, interdependent infrastructure network modeling, transportation system analysis and network modeling, multi-modal transportation system sustainability, traffic signal control and system operation, dynamic and green vehicle routing.

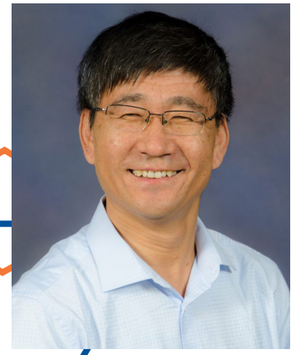
William Eisenstadt

William R. Eisenstadt (SM'92) received the B.S., M.S., and Ph.D. degrees in electrical engineering from Stanford University, Stanford, CA, USA, in 1979, 1981, and 1986, respectively. In 1984, he joined the faculty of the University of Florida, Gainesville, FL. USA, where he is currently a Professor. He has authored or coauthored over 160 referred conference and journal publications. His research focuses on mixed-signal/RF embedded integrated circuit (IC) testing, high-speed I/O characterization, built-in self-test (BiST), and differential S-parameter characterization of IC devices, packages, and interconnect. In addition, he has been involved with large-signal microwave circuit design and test and power-amplifier design. He possesses over 30 years of experience in IC design and test.

Ruogu Fang

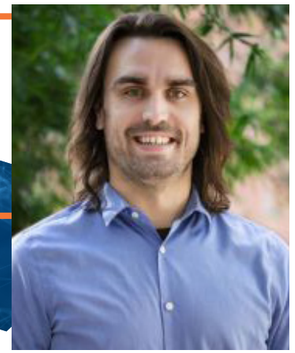
Dr. Ruogu Fang is an assistant professor in the J. Crayton Pruitt Family Department of Biomedical Engineering at the University of Florida. Dr. Fang's research spans data, brain and health. She focuses on questions such as: How to evaluate brain health, via mining the big medical data? She also explores how to make medical imaging higher quality and lower risk for the broad population. Fang's current research is rooted in the big medical data and brain dynamics understanding. Her SMILE lab aims to develop innovative computational models to understand, diagnose and treat brain disorders in big and complex data.

Yuguang "Michael" Fang



Dr. Fang is a professor at the University of Florida Department of Electrical and Computer engineering. He founded the Wireless Information and Networked Things Laboratory (WINET) in 2000. The lab is currently home to graduate students, postdoctoral researchers, and visiting scholars. The group conducts a variety of research on wireless information processing, intelligence extraction, data transportation and control, security and privacy, and network optimization and design, which target at developing technologies for connected and networked things, such as Internet of Things, to improve people's quality of life. Dr. Fang's research interests include Internet of Things (IoT), Connected and Autonomous Vehicles (CAVs), Smart and Connected Health, Security and Privacy, and Fog/Edge Computing.

Matthew Hale



Matthew Hale received his BSE summa cum laude from the University of Pennsylvania and received his MS and PhD from Georgia Tech. His work is driven by designing and analyzing multi-agent coordination algorithms that function well under challenging conditions, such as asynchronous information sharing, noisy communications, and user privacy requirements. His work deploys these algorithms on teams of flying and ground robots, providing both validation of the underlying theory and further research directions.

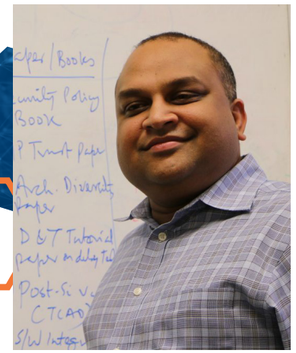
Sanjeev J. Koppal

Sanjeev Koppal is an assistant professor at the University of Florida's Electrical and Computer Engineering Department. He is also the Director of the FOCUS Lab at UF. 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 received his B.S. degree from the University of Southern California in 2003 as a Trustee Scholar. Sanjeev won an NSF CAREER award in 2020 and is an IEEE Senior Member. His interests span computer vision, computational photography and optics, novel cameras and sensors, 3D reconstruction, physics-based vision, and active illumination.

Janise McNair

Janise McNair is an Associate Professor in the Department of Electrical & Computer Engineering at the University of Florida, where she leads the Wireless And Mobile Systems Laboratory. She earned her B.S. and M.S. in electrical engineering from the University of Texas at Austin in 1991 and 1993, respectively, and her Ph.D. in electrical and computer engineering from the Georgia Institute of Technology in 2000. Her current research interests are next generation wireless networks, including 6G, Internet of Things, small satellite networks, sensor networks, and cognitive networks, specifically addressing network management, security, routing and medium access control.

Sandip Ray



Dr. Ray is an IoT Endowed Term Professor at the Department of Electrical and Computer Engineering, University of Florida. Before joining University of Florida, he had a stint in the industry. Most recently, he was a Senior Principal Engineer at NXP Semiconductors. Prior to that, he used to be a Research Scientist at Strategic CAD Labs, Intel Corporation. Before moving to industry, Dr. Ray was a Research Scientist at the Center for Information Assurance and Security, Department of Computer Science, University of Texas at Austin. He graduated with a Ph.D from that same department in December 2005.

Shreya Saxena

Shreya Saxena is as an Assistant Professor at the University of Florida in the Department of Electrical and Computer Engineering in the Herbert Wertheim College of Engineering. At UF, she is affiliated with the Department of Biomedical Engineering, the Department of Mechanical and Aerospace Engineering, the Warren B. Nelms Institute for the Connected World and the Norman Fixel Institute for Neurological Diseases. Before this, Shreya was a Postdoctoral Research Fellow at the Center for Theoretical Neuroscience at the Zuckerman Mind Brain Behavior Institute at Columbia University, working with Liam Paninski and John Cunningham. Here, she was affiliated with the Department of Statistics, and being generously funded by the Postdoc Mobility Fellowship offered by the Swiss National Science Foundation.

Aditya Singh

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.

Gregory Stitt

Dr. Gregory Stitt is an associate professor in the Department of Electrical and Computer Engineering at UF. He earned a Ph.D. in Computer Science from the University of California, Riverside in 2007. His research interests include Reconfigurable Computing, FPGAs, GPUs, synthesis, compilers, CAD, architecture, and embedded systems. He received the Undergraduate Teacher of the Year Award from the College of Engineering at UF in 2014 and the National Science Foundation CAREER Award from 2012-2017.

Roozbeh Tabrizian

Roozbeh Tabrizian is an Assistant Professor and the Alan Hastings Faculty Fellow at the Department of Electrical and Computer Engineering at the University of Florida. He received his B.S. (2007) degree in Electrical Engineering from Sharif University of Technology, Iran, and the Ph.D. (2013) degree in Electrical and Computer Engineering from the Georgia Institute of Technology. He was a Post-Doctoral Scholar (2014-2015) at the University of Michigan. His research interests include RF micro- and nano-electro-mechanical systems (RF N/MEMS), nonlinear, nonreciprocal, and hybrid NEMS for sensing and information processing, and emerging ferroelectric materials and devices. Tabrizian has received a DARPA Young Faculty Award (2019) and an NSF CAREER Award (2018). His research has resulted in more than 60 journal and refereed conference papers.

Shuo Wang

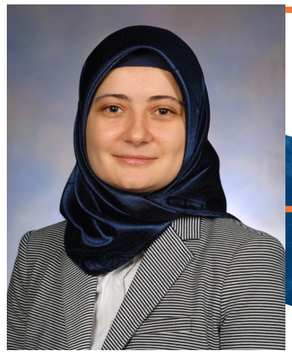
Shuo Wang (S'03-M'06-SM'07-F'19) received the Ph.D. degree in Electrical Engineering from Virginia Tech, Blacksburg, VA, in 2005. He is currently a full professor with the Department of Electrical and Computer Engineering, University of Florida, Gainesville, FL. He has published more than 200 IEEE journal 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.

Dapeng Oliver Wu

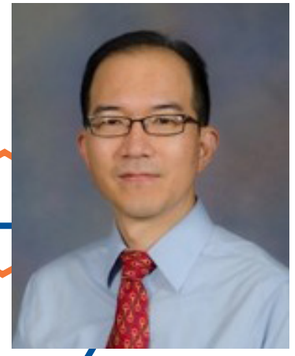
Dapeng Oliver Wu (S'98--M'04--SM'06--F'13) received a B.E. degree in electrical engineering from Huazhong University of Science and Technology, Wuhan, China, in 1990, an M.E. degree in electrical engineering from Beijing University of Posts and Telecommunications, Beijing, China, in 1997, and a Ph.D. degree in electrical and computer engineering from Carnegie Mellon University, Pittsburgh, PA, in 2003. He is a professor at the Department of Electrical and Computer Engineering, University of Florida, Gainesville, FL. His research interests are in the areas of networking, communications, signal processing, computer vision, machine learning, smart grid, and information and network security.

Tuba Yavuz

Dr. Yavuz is an Assistant Professor in the Electrical and Computer Engineering (ECE) Department at the University of Florida. 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, she 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 is still affiliated with the CISE Department as a graduate faculty.



Yong-Kyu "YK" Yoon



YK Yoon is currently an Associate Professor in the Department of Electrical and Computer Engineering at the University of Florida, Gainesville, FL. His current research interests include three dimensional (3-D) micromachining and nano fabrication; design and implementation of metamaterial for radio frequency (RF) and microwave applications; micromachined millimeter wave and terahertz antennas and waveguides; bio/microfluidic systems for the lab-on-a-chip applications; wireless telemetry systems for biomedical applications; and ferroelectric material development for high density memory devices and/or tunable RF devices.