CELEBRATING FIVE YEARS OF

# CONNECTION & INNOVATION

AN IMPACT REPORT ON THE **WARREN B. NELMS** INSTITUTE FOR THE CONNECTED WORLD

UF

# A SPIRIT OF INGENUITY & INNOVATION:

**WARREN B. NELMS WAS ALWAYS TINKERING, TURNING POSSIBILITIES INTO REALITIES FROM A YOUNG AGE.** In high school, he invented an auto-dial system for telephones—an achievement that was merely the first of many instances of Warren's innovative spirit and his unique drive to solve daily challenges. Ahead of his time, he fabricated all the circuit boards and programmed the micro-processors in his award-winning, energy-efficient solar home outside Tampa, crafting a system of custom automations that stand as a precursor to today's Internet of Things (IoT).

This legacy of ingenuity and innovation is what powers the Warren B. Nelms Institute for the Connected World today. Imbued with a tinkerer's spirit and brought to life by the generosity of David Nelms, Warren's son, the **Institute stands at the convergence of research, education, workforce development and the University of Florida's commitment to becoming a global force in the 4th Industrial Revolution**.

Enhanced by the support of Sachio Semmoto and leadership from the Herbert Wertheim College of Engineering, the Institute has grown into a headquarters for today's visionaries that equips them with the skills and resolve to address tomorrow's grand challenges. We are honored to celebrate the fifth anniversary of this vibrant and vital space that is leveraging technology at the cutting-edge of AI and IoT and catalyzing the future for the Herbert Wertheim College of Engineering—and the university as a whole.

**David Nelms (BSME '83, pictured right) alongside his parents, Warren Nelms (BEE '59) and Patsy Nelms (BA' 59)**

*"The Institute has convened a team of talented researchers to pursue truly transformative research in IoT. We are developing innovative and impactful technologies that improve lives and transform industries. Warren's bold vision for intelligent automation and his enduring legacy are constantly inspiring our faculty and students to develop technology solutions designed to solve global problems."*

**DR. SWARUP BHUNIA**, Director, Warren B. Nelms Institute for the Connected World
Semmoto Endowed Professor of IoT

# TRANSFORMATIONAL IMPACT

**SINCE ITS INCEPTION IN 2017, THE NELMS INSTITUTE HAS MELDED IoT INNOVATION AND BEST PRACTICE.** From sensors to software, smart locks to smart lights, the Institute is a national leader in the education and research of how technology connects us all. Thanks to its expert faculty and leading cohort of graduate and undergraduate researchers, the Institute is exploring new ways to use this technology to solve major health, energy, transportation and manufacturing issues while also remaining focused on the privacy and security of people utilizing smart devices. With billions of IoT-connected devices already in the world today—and billions more in the coming years—the Institute will enable UF to remain at the forefront of this burgeoning field while creating a critical mass of expertise at the convergence of AI and IoT.

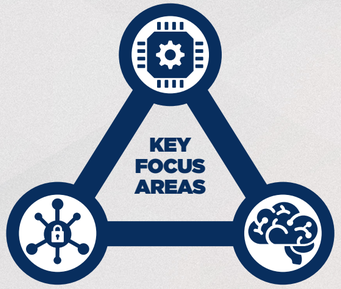
## BY THE NUMBERS

**10+**
National companies sponsoring Institute research, including Intel, Texas Instruments, Amazon, Northrop Grumman*

**$30M**
In research funding (federal & industry) *

**120+**
Student co-authored research publications*

AUTONOMOUS SYSTEMS




IoT SECURITY

AIoT
(CONVERGENCE OF AI & IoT)

**3**
Endowed term professors supported by Nelms gift covering key IoT focus areas

**52**
Institute-affiliated faculty

**80**
Graduate student researchers

**20**
Undergraduate student researchers

**35**
Patents filed*

*Data from 2019 to beginning of 2022 academic year coinciding with appointment of Dr. Bhunia

# INTO THE FUTURE

AS THE AIoT FIELD EVOLVES, DRS. SWARUP BHUNIA, MY T. THAI AND FACULTY MEMBERS OF THE INSTITUTE HAVE IDENTIFIED THREE CORE PILLARS THAT WILL DRIVE THE INSTITUTE'S MOMENTUM AND SUCCESS FOR THE NEXT FIVE YEARS AND BEYOND.

## PILLAR #1 | DESIGNING THE TOOLBOX

Bolstered by the Nelms family's transformational philanthropy and UF's leading AI resources, including HiPerGator AI, the fastest AI supercomputer in higher education, the Nelms Institute is uniquely equipped to develop core technologies and fundamental innovations in IoT hardware, software, networking and AI algorithms that will illuminate the future of AIoT. Dr. Bhunia refers to this work as building the "Toolbox," a series of enabling techniques to utilize advanced IoT and AI principles in support of global industries.

Imagine the Toolbox as a LEGO® play set. The pieces and instructions are provided, but the user selects the right components to build the set. Along the way, they can mix-and-match elements from other sets, modify the arrangement of pieces and create works that are wholly unique. The Toolbox's hardware and software components are the vital building blocks that allow users to address multifaceted challenges by creating efficient and novel AIoT strategies to meet the specific needs of diverse applications. For instance, the Institute is currently:

- **Collaborating with UF's Department of Biology and College of Public Health and Health Professions** to develop a new customizable AIoT platform that tracks, interprets and maps light pollution data and analyzes how light pollution is affecting plants, insects and sea turtles.
- **Working with technology companies to develop IoT security and privacy solutions** that protect our devices and data. Some of these solutions are being applied in autonomous vehicles to accomplish "secure autonomy."
- **Developing fundamental AI models and algorithms** to enable fair and explainable deep learning on IoT devices and beyond.
- **Designing a principled and systematic Federated Learning,** an emerging paradigm of collaborative machine learning to ensure verifiability, execution integrity, model confidentiality and security.


## PILLAR #2 | APPLYING THE TOOLBOX

UF faculty and students from across campus regularly utilize the Institute's resources and have leveraged elements of the Toolbox to create novel applications capable of furthering their research and addressing pressing societal challenges, including:

- **IoT for COVID-19 Protection**

  UF faculty are bolstering the utility of smart wearable devices powered by IoT technology that detect, prevent and mitigate the spread of disease. These prototypes range from wristbands that discern whether individuals are standing too close together, a wearable that detects COVID-19 before symptoms are developed and a mask that cleans the air around the individual wearing the device.

- **Detecting Fake Medicine Using IoT**

  Building on years of research, UF faculty have multiple patents pending for IoT devices that employ a technology once used to detect explosives. It can instantly recognize counterfeit medicine or illegal substances. Fake pills are a growing problem in developed and developing countries as the rise of online pharmacies has sprouted from pandemic precautions. Kelsey Horace-Herron, a Nelms Institute Ph.D. student, formed a start-up company—Resonance Signatures, LLC—that is using the Toolbox to non-invasively detect illegal substances in mail packages and root out these fake medicines.

- **Early AI-based Detection for Neurodegenerative Diseases**

  UF faculty are working to build confidence in AI for health care, especially developing non-invasive AI-based techniques for early detection of neurodegenerative diseases. Developing trustworthy and explainable tools will have a significant impact, not only in health care but also to any application that uses AI for predictions.

- **IoT-Enabled Smart Supply Chain**

  A dangerous rise in counterfeit products across all industries has become a major threat to the global economy. Using IoT devices, UF faculty have discovered a novel nanodot technology to create unique identification labels to ensure logistics companies can discern between authentic and counterfeit products.

- **Cloud Controlled Charging On The Go Using IoT**

  Using innovative IoT technology and the power of cloud computing, UF researchers have discovered methods for electric vehicles to recharge while driving—addressing battery life issues and range anxiety. A central management system that is cloud-operated with the ability to recharge any mobile device—electric vehicles, delivery drones, cell phones—could tremendously reduce charge time, increase efficiency across the supply chain and address rising climate change concerns.

## PILLAR #3 | EDUCATION & OUTREACH

**AIoT IS AN EVOLVING TECHNOLOGY, AND MANY UNIVERSITIES LACK THE PROPER CURRICULAR RESOURCES TO TEACH RELEVANT COURSES IN THIS SPACE.** The knowledge gap is even more prevalent in high schools, with few across the nation providing any hardware or software studies for students. At the same time, there is a growing need among technology-focused companies to have access to a workforce pipeline that is trained in and equipped to use important aspects of AIoT in their careers.

UF, with its suite of AI resources and the IoT expertise possessed within the Nelms Institute, is positioned to develop a curriculum that bridges the knowledge gap in AIoT by creating practical training modules that can be used by a wide variety of scholars—from high-schoolers to doctoral researchers. This "hands-on/minds-on" approach is the backbone of the Institute's envisioned IoT Academy, which is creating take-home modules students can use to learn key aspects of IoT, cybersecurity and AI. This collaboration with UF's College of Education has received funding from the National Science Foundation and National Security Agency (from its GenCyber Program) to create innovative cybersecurity modules for high school students.

Building on this successfully funded model, the Institute has submitted additional grant proposals that will help the IoT Academy create dynamic summer courses for high school students and UF undergraduates. This next phase of the IoT Academy is tied to a collaboration with the University of Kansas and Texas Instruments, which donated hardware modules that provide a gamified learning approach to AIoT hardware. The Institute is currently waiting on $600K in funding to help roll out this program nationally, starting with Alachua County.

The Institute also regularly disseminates its research nationally and convenes leading experts in the AIoT space during impactful workshops, panel discussions and seminars—held both online and in-person. The Institute's first annual conference hosted more than 200 attendees from across the country and featured more than 80 posters and IoT demos. This momentum continued during the pandemic through virtual workshops, including the second annual Women in IoT Workshop focused on "AI on the Edge," which had over 270 registered attendees from across the world.

*"In alignment with the university's commitment to becoming a global force in AI, our workshop will significantly grow at the convergence of AI and IoT. It has been enriched through the participation of many outstanding female leaders and role models. We look forward to addressing the gender gap issue in the field of AIoT, impacting more women on their career adventures."*

**DR. MY T. THAI**, Associate Director, Warren B. Nelms Institute for the Connected World
Professor of Computer & Information Science & Engineering

**THE INSTITUTE HAS ALSO SUPPORTED THE GROWTH OF AN ENTIRELY STUDENT-LED IoT CLUB THAT RECENTLY HOSTED ITS FIRST NATIONAL IoT DESIGN COMPETITION.** The event required undergraduate student teams to design, build and demonstrate the functionality of an IoT device created to solve a real-world problem. Ten university student teams from across the country competed for $6K in cash and prizes provided by event sponsors Texas Instruments and Microsoft.

*"The IoT Students Club has been growing every year since we started in 2019. Our first event brought together students from across the country and some amazing sponsors. We hope to continue to grow the club and plan even more exciting competitions moving forward."*

**REINER DIZON**, Third-year Ph.D. student,
Nelms Institute

# UNLIMITED OPPORTUNITY

**WITH UNMATCHED ACCESS TO CUTTING-EDGE AI RESOURCES, A MOTIVATED AND TALENTED GROUP OF FACULTY AND SCHOLARS ADVANCING THE FRONTIERS OF IoT RESEARCH AND EDUCATION AND A STEADY STREAM OF FEDERAL AND INDUSTRY FUNDING**, the future of the Warren B. Nelms Institute for the Connected World is bright. The Institute is scheduled to relocate to the Malachowsky Hall for Data Science & Information Technology, UF's new hub for AI, in summer 2023. This new space will provide a vibrant and intellectually engaging headquarters for future generations of tinkerers and visionaries—ensuring the Institute's next five years are just as groundbreaking.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