

**NORTH CAROLINA A&T STATE UNIVERSITY**  
**INFORMATION SCIENCES AND TECHNOLOGY (IST) CLUSTER**  
**WHITE PAPER**

## **Vision**

The Information Sciences and Technology research cluster at North Carolina A&T State University is a collaborative effort among the College of Engineering, the College of Arts and Sciences, and the School of Technology. This cluster addresses the sciences, mathematics, and technologies relevant to gathering, processing, understanding, and communicating information. The vision of the cluster is to take a leading role in combining information technology (IT) resources and faculty expertise listed above to foster an interdisciplinary environment in support of research and educational endeavors. The academic departments primarily involved in this cluster's research include the Departments of Electrical and Computer Engineering; Computer Science; Industrial Engineering; Mathematics; Physics; and Electronics, Computer, and Information Technology.

Advances in information sciences and technology have dramatically transformed how people live, work, learn, communicate, and conduct business. The IST cluster is part of one of the fastest growing technological and scientific sectors, one that continues to revolutionize society. At the turn of the Twenty First Century, IST is still a rapidly-growing, revolutionary field driven by the explosive creation of knowledge and information (as evidenced by the World Wide Web) and by the need to successfully manage and fully use this growth. Ubiquitous sensing, computing, and communication are now merging with a growing ability to perform abstract thinking, sense-making, and verbal communication.

## **Impact**

Technologies developed and advanced within this broad topic will impact many areas including the following:

- Aerospace Applications – tools using IST to help with the exploration of space, remote sensing from satellite systems, and Geographic Information Systems.
- Health Care - tools for information sharing, data mining, and minimally intrusive medical imaging that can reduce the cost of health care and increase its efficacy. Additionally, advanced drug delivery systems allowing precise doses of medicines to be delivered on an as-needed basis.
- Workplace Productivity - tools that enable workers to collaborate, communicate and create more effectively will have a profound impact on the economy.
- Environment - tools for monitoring the environment and creating less pollution both domestically and abroad, particularly in developing countries.
- Military Applications - technologies for communication, command, control, surveillance, and guidance; all important for the nation's defense.
- Education Delivery - As pressure increases to better educate students, especially in the K-12 grades, IT tools are being developed to augment the skills of

educators. NCAT researchers developed technologies as simple as calculators and as complex as learner-paced tutorial systems.

In addition, new information technologies are being aggressively developed because of their potential for economic impact.

## Definition and Scope

Information Sciences and Technology can be defined as both the fundamental design and the application of computers, sensors, actuators, networks, and communication systems, and the study of their associated societal impacts. These systems are increasingly pervasive and less distinct as separate systems. For example, an automobile contains no less than six computers, has three separate communication systems, and numerous closed-loop control systems. Is a car the product of information science and technology? Perhaps not, but information science and technology are critical to the modern automobile.

Major research thrusts and their applications are as follows.

- Communication, Computing, and Processing Systems with applications in wireless communications, environmental and security monitoring, ubiquitous sensing, and biomedical devices.
- Computational and Artificial Intelligence and Thinking Systems with applications in bio-informatics, linguistics, sense making, and information assurance with a large number of applications in the military and commercial sectors.
- Control and Decision-Making Systems for industrial, economic, and military applications.
- Internet-Based Applications for communication, security, commerce, education and cooperative industrial design.
- Robotics with space, security and industrial and quality-of-life applications.
- Sensor Systems for environmental, residential, and military applications.

## Technologies and Applications

Information Sciences and Technology cluster research will encompass a broad range of fundamental and applied research. Researchers will develop algorithms, architectures, materials, devices, systems, and protocols.

### *Communication, Computing, and Processing Systems*

These systems are responsible for communicating, storing, and disseminating information efficiently. Examples are familiar and abundant such as computers or cellular phones. Related areas of research are algorithms and architectures for computer systems that can store or retrieve relevant information.

Researchers at NCAT have developed microelectronic VLSI chips, novel materials and devices for computers and displays, and reconfigurable and fault tolerant circuits. In addition, they have conducted research on:

- Electronic chip design and fabrication;
- Energy- and bandwidth starved sensor networks;
- Acoustical communication and signal processing;
- Communication and ad hoc networks;
- Environmental monitoring;
- Ad hoc self organizing networks, radar;
- Global positioning systems

### *Computational and Artificial Intelligence and Thinking Systems*

The ability to build intelligent systems to help humans and societies perform their tasks has led to the pursuit of the now classical Artificial Intelligence disciplines, which emphasize rules and syntax. A more modern and computationally-demanding approach is known as computational intelligence; it emphasizes discovery and semantics. Together they enable us to build intelligent machines and computers.

Researchers at NCAT have been involved in developing the following:

- Algorithms for scientific computation
- Natural language and speech processing
- Intelligent systems evaluation
- Cryptography
- Information security
- Computational and artificial intelligence
- Feature extraction, image processing, GIS, and environment exploration
- Computer languages
- Electronic book technology
- Formal software methods
- Software quality
- Statistical and mathematical modeling; data mining, machine learning
- Sense making inference and logic, war games
- Information fusion formal methods

### *Control and Decision-Making Systems*

These systems are common to both natural and man-made systems. Feedback loops are used everywhere to control, regulate, adapt, and stabilize; life would be impossible without them. Feedback loops stabilize the temperature of the healthy human body or the temperature inside the house. In all cases, a controller (possessing some level of sophistication or intelligence) gathers information about the environment using sensors,

processes this information, and reacts to the environment using available mechanisms, machines, etc. More sophisticated control systems are called decision-making systems such as the supervisory control ensuring the reliability of the electric power utility network spanning the whole of the continental United States.

Researchers at NCAT have conducted research in the following aspects of control and decision making:

- The control of port-based and shipboard cranes for transfer of cargo in tumultuous seas
- The control of the atmospheric reentry maneuvers of the Space Shuttle
- The control of motor drives and electronic power systems such as those used in air conditioning systems
- The control of the motion of industrial and mobile robots
- Quality control of manufactured materials and regulation of the conditions under which they are produced.

### *Internet-Based Applications*

The internet has become a crucial part of our daily lives, and there are many disciplines that seek to improve the usage and quality of this service. Clearly there are many commercial, entertainment and educational applications available on the internet.

NCA&T researchers have conducted research in the following aspects of internet technology:

- Pervasive, wireless, and multimedia computing; advanced networking,
- Internet-based applications e-commerce, computer security and information assurance,
- Distributed information processing,
- Operations research and system design manufacturing systems,
- Object oriented design, decision support, information systems, modeling and simulation, and
- Biometrics for computer access and security

### *Robotics*

Robotics is the discipline through which one designs machines that mimic the human body and mind or extend its capability. Increasingly the term is being applied to all unmanned vehicles (underwater, sea and air vehicles, etc.) that mimic the capabilities of nonhuman species. Robots are indispensable in manufacturing where they replace humans in doing tedious or dangerous jobs. They are used increasingly in aerospace, military, or even entertainment.

NCA&T researchers have conducted research in the following robotics related topics:

- Mobile, autonomous robots; load carrying robots;
- Man-machine interfaces and teleportation
- Biometrics, and robots improving the quality of life
- Robotics coordination
- Cooperation and complex behavior such as swarms of unmanned vehicles
- Biometrics and ergonomic designs

## *Sensor Systems*

These systems are responsible for gathering information about our environment whether natural or man-made. These systems are generators of information that can be processed and utilized later. A recent upsurge of sensors technologies has made sensor cheap and ubiquitous, presenting vast new opportunities and challenges. Organizing these sensors into large wireless energy-starved ad hoc networks is a very promising technology development direction.

NCA&T researchers have conducted research in the following areas:

- Acoustical sensing mechanisms for classification of cars and for structural health monitoring
- Development of chemical, nuclear, and biological sensors for security and environmental applications.
- Development of ad hoc networks for 911 emergency and military applications.
- Development of sensor and information fusion algorithms to present a more complete version of the world, with military, biomedical, and robotics applications.

## Strengths (NOT YET COMPLETE)

Strong graduate programs currently in place at North Carolina A&T State University support IST research. These programs include masters and doctoral level programs in Electrical Engineering and Industrial Engineering. Also, the new Master of Science in Computational Science and Engineering (together with the Master of Science programs in Computer Science, Mathematics, and Industrial Technology) with a concentration in Information Technology will form a solid base of support for fostering a culture that synthesizes faculty expertise and educates students to conduct research in an interdisciplinary environment.

Current information technology projects that can be leveraged to support Information Sciences and Technology Cluster research include, but are not limited to:

- Wireless IC design (ECE, MFG, and ECIT)
- Wireless and mobile communication (ECE, and ECIT)
- Global positioning technology (ECIT)
- High performance computing (ECE, and ECIT)

- Authentication and verification technologies/ biometrics (ECE)
- Sensor development (ECE)
- Mobile and intelligent robotics (ECE)
- Man machine interfaces (IE, ECE)
- Thinking systems and machines (ECE, CS, and IE)

## Assets (NOT YET COMPLETE)

The following laboratories and center form the nucleus for research in the area of Information Technology. These labs represent an interdisciplinary effort by the various Schools and Colleges at the University in which they reside to develop the core competencies in the area of Information Technology research.

- IMIS
- RF device verification
- Wireless laboratory
- ASIC design laboratory
- Cyber defenders
- Center for Autonomous Control and Information Technology
- Wireless geo-location and communication laboratory
- Bioinformatics learning facility
- Advanced robotics laboratory

The success of an Information Sciences and Technology research cluster is heavily dependent on resources allotted to the above-mentioned labs and centers.

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## Appendix

Wireless communications and mobile communications - these areas are the broadest in this list. They encompass:

Sensor webs - the use of distributed, collaborative, self-aware sensors can provide Self-Configuring Networks, networks for Robotics, autonomous vehicles, teleoperated devices Radios, CDMA, OFDM, Software radios Chip Technologies, CMOS, SOI, GaAs, SiGe.

Miniature devices - this includes MEMS, micromanipulators, miniature drug delivery systems

Control systems - traditional closed loop control, fuzzy control, and neural network-based control

GPS - the satellite-based positioning and navigation system based on precise measurement of time-of-flight of signals from orbiting transmitters.

Privacy research - shared access to sensitive data must be protected.

Grid computing/ massively parallel computing - problems once solved by Supercomputers are now being solved using a collection of workstations

Computer security & network security - the use of computers and networks must be protected from unauthorized use

Artificial intelligence - algorithms that use rules of logic to emulate intelligence

Image and pattern recognition - objects and patterns are extracted from images and signals

Signal processing (image processing) - the application of transforms to manipulate signals and images

Human-machine interface - the display, control and status interface between a system and its user

Pervasive computing/ ubiquitous computing - widespread use of computers and embedded computing