Research Horizons

WINTER 2000

COVER STORY

Sensing the Subleties of Everyday Life

Aware Home with human-like perception could improve the quality of life for many, especially senior adults.
By Jane M. Sanders

Editor's Perspective *— Jane M. Sanders*

FEATURES

Contravening Contraception

New book recalls government ban on contraceptives and tracks the industry's development.
By Jane M. Sanders

Involving the Pilot in Air Traffic Control

How much information is enough to give pilots more involvement in air traffic management?
By Jane M. Sanders

Connecting the Dots

GTRI helps create new networking standard for defense simulations
By Gary Goettling

Designing with Humans in Mind

Internet-based design tools will aid traffic management center planners in minimizing potential for operator error.
By Jane M. Sanders

FEATURES

Better than Human Flight Control Systems

Re-engineered neural networks are dramatically changing control of aircraft.
By Rick Robinson

Pulp Non-Fiction

New papermaking technology truly means less is more.
By T.J. Becker

Pandamonium

Tech partners with Zoo Atlanta to help preserve pandas.
By Amanda Hainsworth

DEPARTMENTS

Faculty Profile

Educational software developer believes in learning it by doing it.
By Jane M. Sanders

Research Notes

- Food Safety
- The Cost of Cleaning the Air
- Charging Through DNA
- Where Oil and Water Mix
- MRI for Carpets and Fabrics
- Measuring Smallest Air Pollutants

Research Links

- Measuring Environmental Performance
- Smarter Web Browsing
- Mammograms at Internet Speed
- Endowing Research
- Awards and Honors

Would You Like to Be My Neighbor?

State-of-the-art research "neighborhood" complexes will promote collaboration and foster economic development

By Jane M. Sanders

Research Horizons
Volume 17, Number 2
Winter 2000
A publication of the
Georgia Institute of Technology

Editor
Jane M. Sanders
jane.sanders@edi.gatech.edu
404/894-2214

Contributing Writers
Amanda Allen
Lincoln Bates
T.J. Becker
Gary Goettling
Amanda Hainsworth
Jackie Nemeth
Rick Robinson
Jane M. Sanders
John Toon

Photography
Defense Visualization Information Service
Caroline Joe
Stanley Leary
Gary Meek
PhotoDisc Inc.

Graphic Design
Everett Hullum
Matt Hullum

Illustration
Mac Evans

Web Design
Rick Robinson

Administration
Dr. Edward Reedy
Director, GTRI, and Vice President, Georgia Tech
Dr. Charles Liotta
Vice Provost for Research and Dean of Graduate Studies, Georgia Tech

Research Horizons is a member of the University Research Magazine Association. For more information, point your browser to www.urma.org.

Research News & Publications Office
Georgia Institute of Technology
430 Tenth Street, N.W.
Suite N-116
Atlanta, Georgia 30318
(Telephone: 404/894-6986)

ISSN #1060-6696

Research Horizons readers may subscribe to the electronic version of the magazine by sending an email message to listproc@gtri.gatech.edu. The body of the email message should read "Subscribe rh.subscribers." Subscribing to this distribution list will alert you to new issues of the magazine as they are posted on our Web site. If you wish to stop receiving these reminder messages, you may send an email message to listproc@gtri.gatech.edu. The body of the email should read "Unsubscribe rh.subscribers."

ResearchHorizons

Sensing the Subtleties of Everyday Life

"Aware Home" with human-like perception could improve quality of life for many, especially senior adults.

By Jane M. Sanders

Your aging mother lives alone. She could fall. She could forget to take her medicine. She might incorrectly set her heater in winter. She could be depressed and lonely. You worry whether she should continue to live by herself, but her contentment is so closely tied to the place she has called home for so long.

This dilemma is all too common as the Baby Boom generation ages and people live longer.

But imagine a network of sensors and computers installed throughout your mother's home. The system could warn her of impending problems, remind her of important routines, encourage her to get some exercise and even call emergency services, if it could not get her to respond.

Scary or exciting as this type of decision-making computer network may sound to you, it's probably going to be a reality early in this century. Its applications are far reaching and seemingly only limited by human ingenuity.

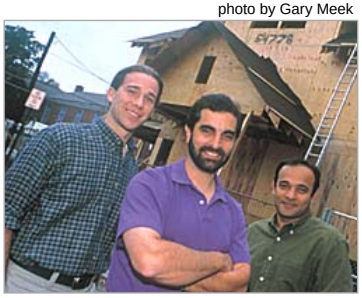
Computers with human-like perception will emerge as society breaks away from the traditional desktop computer and moves into the era of ubiquitous computing. Also known as ubicomp, it refers to an environment where computers are constantly present, seamlessly integrated and applied for everyday uses.

"The traditional desktop computer helps to an extent with daily life," says Dr. Irfan Essa, an assistant professor in the Georgia Institute of Technology College of Computing. "But we believe the computer should not be limited to the desktop. It should be a part of the room."

If computers are constantly present, then they should also be smarter, according to researchers in Georgia Tech's Future Computing Environments (FCE) group.

"The next generation of technology will have computers understanding what people are doing and what they want," says Associate Professor and FCE Co-founder Dr. Chris Atkeson. "The basic expectation is that humans have a clue. For now, computers don't have a clue."

photo by Gary Meek



The Broadband Institute Residential Laboratory under construction near the Georgia Tech campus will host a broad range of communications-related research, including a College of Computing project called "Aware Home." Faculty members Dr. Gregory Abowd (center) and Dr. Irfan Essa (right) are among the researchers and students, such as Corey Kidd (left), who are investigating ubiquitous and aware computing concepts. (300-dpi JPEG version - 454k)

Since 1995, the FCE group has been investigating the ubicomp and aware computing concepts in "living laboratories." These are technology-rich Georgia Tech classrooms, offices and now an experimental house called the Broadband Institute Residential Laboratory. The researchers, who make up the FCE research team, refer to their work there as the "Aware Home" project.

When the Residential Laboratory opens early this year near the Georgia Tech campus, the house will be capable of knowing information about itself and the whereabouts and activities of its inhabitants.

The laboratory, under the guidance of The Broadband Institute, was funded by a $700,000 grant from the Georgia Research Alliance. The 5,040-square-foot house will host a broad range of communications-related research funded by a consortium of more than 20 information technology companies, says Broadband Institute Director Dr. Nikil Jayant.

The three-story Residential Laboratory includes: a basement with a high-performance computing and shared home entertainment section; and two independent, two-bedroom living areas. One living area will serve mainly for experimental purposes; the other will host actual residents, initially students and eventually an elderly person or family.

"Aware Home" researchers want to build an environment that can sense the inhabitants by seeing, hearing and measuring contact through a variety of sensing technologies, including video, audio, motion and load.

photo by Gary Meek

Researchers created a prototype "aware" room to test sensor technologies that make a computer's perception more human-like. (300-dpi JPEG version - 525k)

"We will be breaking new ground with the Aware Home," Atkeson says. "The computer will be aware of who people are and what they are doing, rather than needing a human being in charge of the remote control, for example. This is the next generation of computing."

With the expertise of seven full-time faculty members, the FCE group is working as a team "to demonstrate how ubiquitous computing can impact favorably and possibly negatively," says Assistant Professor and FCE Co-founder Dr. Gregory Abowd. "We want to understand those different impacts of technology. Aware Home is our next big frontier."

Researchers in the FCE group are simultaneously focusing on human- and technology-centered studies in the Aware Home.

"The human challenge with this technology is as much a challenge, if not more than the technological challenge," Abowd says.

Researchers want to prevent information overload, avoid invasion of the occupant's privacy and create practical ubicomp applications for the

everyday user. They have determined the most important potential users initially are senior adults.

An Aware Home initiative called "Aging in Place" is aimed at finding ubicomp technology applications that will allow senior adults to live independently in their homes as long as possible. The benefits are both social and financial.

Eventually, ubicomp technology in the home might be less costly that the $2,000 or more per month it can cost to live in an assisted care or nursing home facility, says Assistant Professor Dr. Beth Mynatt.

Specifically, "Aging in Place" would program the Aware Home to: sense and identify potential crises, and then automatically contact services as needed; augment a senior adult's memory; and track behavioral trends by creating social connections between senior adults and their relatives.

In terms of crisis intervention, basic sensing technology could help relatives determine when an incident has occurred or prevent it from occurring. For example, the Aware Home could alert the resident when the home is getting dangerously cold. It could ask, "Are you doing this on purpose?" Researchers, including Dr. Wendy Rogers in the Georgia Tech School of Psychology, are addressing how to effectively communicate with occupants.

Another goal of "Aging in Place" is memory augmentation, or cognitive support, which helps people in their day-to-day routines. For example, senior adults often deal with the difficult problem of interruption. If senior adults are preparing a meal and get interrupted by a knock at the front door, they sometimes need help remembering what they were doing when they return to the kitchen. The aware system would jog their memory by offering displays of key snapshots taken by vision sensors in the kitchen before the interruption.

The third objective, behavioral trend tracking, is what Mynatt calls "the peace of mind quotient." She and her students created "Digital Family Portraits" for family members to follow their senior relatives' routines and activities, both daily and over time. It also gives senior adults insight into their relatives' lives.

The frame of the picture, which would be a flat panel display, is dynamic. Age-appropriate, engaging icons in the frame can give relatives a sense of how the senior adult is doing, Mynatt explains. The icons represent notions of health, relationships, activity and events. Using sensing technology, the Aware Home can get a general sense of whether the senior adult interacted with a lot of people today, for example.

The three bands in the frame represent different periods of time. The center band represents today, the second band represents a summary of the past four days and the third represents the past two weeks. Icons in the band decrease in size from the center to the outer bands to represent the various time periods. The icons vary in density to represent quantity in each of the four categories. Then family members could recognize, for example, that their senior relative's activity level seems to be going down over time. That might prompt them to investigate further.

"They won't necessarily be diagnosing the problem; it's just that this sort of contact makes the situation seem less scary," Mynatt says.

photo by Gary Meek

Sensors in the furniture and in the windows are among the "Aware Home" components. They will help residents and researchers monitor activities in the home. (300-dpi JPEG version - 547k)

In the technological arena, FCE researchers are studying how ubiquitous sensing can give computers a decision-making context, like humans have. In the Aware Home, Essa, Associate Professor Dr. Aaron Bobick and other researchers are building a context-aware development infrastructure they have tested in a controlled situation in an office.

"Imagine a computer that knows you are near it, knows you are looking at it, and knows who you are and what you are trying to do," Essa says. "Such abilities in a computer are hard to imagine, unless it has an ability to perceive people."

In the Residential Laboratory's Aware Home, researchers hope to make computers perceive things and interact with the user. Various types of sensors capture information on the user, including their location, facial expressions and gestures. The computer might be able to determine, for example, if the user is angry or in pain. The intent, Essa adds, is to make the sensing transparent to the user and in no way create a burden.

Meanwhile, Atkeson and other FCE researchers want to build fundamental models of human behavior to train computers in decision making.

"Can we start to learn the preferences and model the behavior of people in the house by watching what they do?" Atkeson asks. For example, during the workweek when they wake up early, the computer system would turn on the coffee maker. On the weekend, when they sleep later, the coffeepot would be programmed to start later.

The Aware Home's context-aware infrastructure will also interact with wearable computers the occupants may use. Researchers led by Assistant Professor Dr. Thad Starner, a widely known authority on wearables, will explore that interaction.

Another technology-centered investigation at the Residential Laboratory will involve a system called the "Smart Floor," a natural input device that can identify and locate a person based solely on his or

Broadband Institute Residential Laboratory

The Broadband Institute Residential Laboratory was founded to conduct research on the confluence of broadband communications and lifestyle computing, and their potential impact on quality of life.

In addition to the Aware Home project, other research in the Residential Laboratory will focus on its use as a "connected home," with all forms of broadband communications into and in the home. In fact, the aware capabilities in the residential lab will depend on communications connectivity, explains Broadband Institute Director Dr. Nikil Jayant.

The Residential Laboratory will serve as a core research facility for a variety of Georgia Tech groups, including the School of Electrical and Computer Engineering (ECE), the Information Security Center and the School of Textile and Fiber Engineering. For example, textile and ECE researchers may collaborate on adding wireless connectivity to a wearable motherboard designed by textiles Professor Dr. Sundaresan Jayaraman. Then senior adults wearing the motherboard could send out signals from sensors monitoring their medical condition. Other examples of their work include cross-collegiate experiments in wireless multimedia, ubiquitous computing and private telemedicine in the home.

A consortium of more than 20 information technology companies will fund research in the Residential Laboratory. Among those companies are BellSouth, Eastman Kodak, EchoStar, Intel Corp., AT & T Corp., Nortel, Broadcom, Convergence.Com, Cox Communications, Digital Furnace, Ericsson, General Instruments, Lucent, Motorola and Sprint. "The consortium is interested in the technology as well as the applications of it," Jayant says. "Most of our sponsors have a fairly broad outlook on research to be conducted in the Residential Laboratory, and its long-term impact."

— Jane M. Sanders

her footsteps. Ten strategically sized and located, force-sensitive load tiles will be installed in the home to gather footstep data from occupants. Researchers believe the system can correctly identify the user more than 90 percent of the time. The system's applications are in trend tracking, crisis intervention and security, among others.

Finding lost objects is yet another tracking and sensing technology researchers will study in the Residential Laboratory. The system will use small radio-frequency tags attached to various objects (keys, wallets, glasses and remote controls) the user wants to track and a long-range indoor positioning system to track these objects. The user will interact with the system via LCD touch panels placed strategically throughout the house. The system will guide the user to the lost object using spatialized audio cues (e.g., "Your keys are in the bedroom.").

Researchers acknowledge the system isn't foolproof. Another person may walk off with the keys, for example. In these cases, other tracking technologies, such as the "Smart Floor," can assist in locating the objects. For instance, if the keys were last seen with Sue at the front door at 8 a.m., the system can inform the user of this fact. The user can then conclude that Sue accidentally took the keys with her to work.

photo by Gary Meek

Ten strategically sized and located, force-sensitive load tiles (shown here) will be installed in the Residential Laboratory to gather footstep data from occupants. Called the "Smart Floor," the system is a natural input device that can identify and locate a person based solely on his or her footsteps. (300-dpi JPEG version - 619k)

All of this technology must be seamlessly integrated, and that software challenge faces Assistant Professor Dr. Blair MacIntyre. "Figuring out how to use different displays for what purposes is a problem that interests me," he says.

If the future is ubicomp, how long will it take to get there? Estimates vary, but FCE researchers believe houses equipped with Aware Home technology could be available within a decade. With ads now for "Smart Home" devices, consumers might wonder what more they might need in 10 years. But Aware Home technology is really different.

"The critical difference is the current technology has people telling computers what to do," Atkeson says. "The next generation of technology will have computers understanding what people are doing and what they want."

But researchers have a difficult task facing them. "There's a lot of technology development ahead of us to be able to do these things," Essa says. "But it's exciting to have the Aware Home as another avenue to explore computational perception. The house takes this research to the real world."

Jayant, who's in the position of overseeing research in the Residential Laboratory is determined to take full advantage of this "real world" experimental environment. "We want to make sure that two to three years from now we have measurable results, that we really did important work here," Jayant says. "... Our goal is to find the most applicable technologies for the everyday user."

For more information, you may contact Dr. Gregory Abowd, College of Computing, Georgia Institute of Technology, Atlanta, GA 30332-0280. (Telephone: 404-894-7512) (E-mail: gregory.abowd@cc.gatech.edu)

center photo: ©1999 Photodisc

Digital Family Portraits created by Dr. Beth Mynatt, an assistant professor of computing, help family members follow senior relatives. The picture frame, which would be a flat panel display, is dynamic, using icons to give a sense of how the senior adult is doing. (300-dpi JPEG version - 454k)

Research Horizons

Perspective

Georgia Tech research will help shape the 21st century's megatrends.

By Jane M. Sanders

Here we are — finally. The year 2000 has arrived. Anticipation fills the air. Opportunities and challenges are everywhere around us. Collectively and individually, we wonder what the 21st century will bring and how we can make valuable contributions to it.

Citing what he believes the century holds in store, Georgia Tech President Wayne Clough recently pointed to several megatrends that present opportunities and challenges for the Institute.

- Technology is ubiquitous.
- Computing is pervasive.
- Internet plus information equals unlimited access.
- Talent is dominant.
- The population is diversified.
- Interdisciplinary is "in."
- Entrepreneurs have the edge.
- The economy is globally networked.
- Research drives innovation.

Georgia Tech must not merely respond to these megatrends, but also use them to its advantage, Clough says.

In this the first issue of Research Horizons in year 2000, we provide evidence that Georgia Tech has already begun its journey on the path that Clough has mapped.

Our cover story on future computing environments hinges on the notion of ubiquitous and aware computing that could improve the quality of life for everyone, particularly senior adults, within the next decade. Researchers from several disciplines have begun a host of

communications-related research at the new Broadband Institute Residential Laboratory. The unrivaled computational perception and connectivity tested in this "living laboratory" will certainly result in technological innovations that will dramatically change our everyday lives.

Interdisciplinary is definitely in at Georgia Tech. The concept is fueling the multi-million construction of Tech's largest and most sophisticated research complexes. The state-of-the-art buildings will key on the idea of "research neighborhoods" that promote interaction among scientists and engineers.

Talent, entrepreneurship economic development are evident in our articles on three new, high-tech start-up companies that sprang from Georgia Tech faculty research.

As always, our contents offer information on research that is driving innovation. From defense-related projects to food safety devices to air quality measurements, Georgia Tech researchers are busy shaping the technology of the 21st century.

ResearchHorizons

Contravening Contraception

Book recalls government ban on contraceptives and tracks the industry's development.

By Jane M. Sanders

Julius Schmidt and Rosemarie Lewis were two American entrepreneurs who recognized and met consumer demand, despite a federal product ban that jeopardized their livelihood. In the late 19th and early 20th centuries, these entrepreneurs invented and sold homemade contraceptive products, which were banned under an anti-obscenity law passed by Congress in 1873. The ban left consumers of black market products unprotected, and sometimes the human costs were high.

Their stories and many others, along with "big picture" events such as the invention of the birth control pill, will be documented in a history of the U.S. contraceptive industry to be published by Hill & Wang. The book, "Devices and Desires: Women, Men and the Commercialization of Contraception, 1873-1973" will be the second by Dr. Andrea Tone, an associate professor in the Georgia Institute of Technology's School of History, Technology and Society.

photo by Stanley Leary

"The government failed consumers in a way the market did not," Tone says, describing one of the book's major findings. "But in the absence of consumer protection, many forms of black market birth control — from condoms with holes to one-size-fits-all diaphragms — caused pregnancy, pain and even death."

Researcher Dr. Andrea Tone became a detective to write a history of the U.S. contraceptive industry to be published next year by Hill & Wang. The book, "Devices and Desires: Women, Men and the Commercialization of Contraception, 1873-1973" is Tone's second. (300-dpi JPEG version - 538k)

Tone's research has revealed two other important, and surprising, facts, she says: Women were active entrepreneurs in the black market birth control trade, and men demonstrated extensive knowledge of contraception and played a larger role in birth control decisions than previously thought.

"Surprisingly little has been written about the technological and industrial developments in contraception that have been important in transforming the lives of women and men," Tone says. "This book will break new ground by showing what it was really like to produce, buy or use contraceptives in a century that saw the contraceptive industry's transformation from an illicit trade headquartered in basement workshops and pornography outlets to one of the most successful 'legitimate' businesses in American history."

With little written history available about the birth control business, Tone had to conduct research like a detective investigating a case, she says. She pored through records of patents, arrests, the Food & Drug Administration (FDA), Federal Trade Commission (FTC) and the American Medical Association. She gathered oral histories from doctors and even reviewed Victorian love letters to document how ordinary people acquired and used illegal birth control.

Georgia Tech's extensive collection of patent records revealed that inventors attempted to circumvent the contraceptive ban by renaming their devices, using terms such as "womb veil" and "married women's device." Still, those opposing contraception led passionate crusades against it. For example, arrest records of the New York Society for the Suppression of Vice, active in the late 19th century, recorded very detailed descriptions of contraceptive manufacturers and their illegal wares.

"It was remarkable to see how many people across the country were still active in the birth control trade," Tone says. "... Even though there were laws in place against it, there was a very lively bootleg business."

Tone came across many fascinating examples of entrepreneurship, including partnerships between men and women, as well as women inventors of birth control devices during the contraceptive ban.

"While many contemporaries denounced female entrepreneurship as 'unladylike,' the contraceptive business had already been branded illegitimate," Tone says. "This stigma served businesswomen well, creating an economic arena that tolerated, even cultivated, women's commercial activism. Good credit and connections, essential tools for business

success traditionally denied women, were less fundamental to the business of birth control than others. . . .

"But when large corporations began to take over birth control production in the 1930s, the heyday of entrepreneurship — for women and everyone else — came to a dramatic close," Tone says. "New technologies of production, and the regulation that came with legal liberalization, made it hard for smaller players to compete."

Such was the case with Los Angeles' Rosemarie Lewis, whose diaphragm and contraceptive jelly business is documented in FTC records that Tone found. Lewis made the one-size-fits-all devices in her home and sold them door to door on an installment plan to working class people in the 1920s and '30s. By the late '30s, Lewis was one of the top 10 diaphragm and jelly makers in the country. But as birth control became legalized, large manufacturers complained to the FTC that Lewis' products were less effective than theirs. The FTC charged Lewis with false advertising, eventually putting her out of business.

There was also New York's Julius Schmidt, a late 19th century sausage casing maker by day and condom maker, using animal intestines, in his home at night.

Endowment for the Humanities grant at the Huntington Library Archives near Los Angeles provided access to love letters of people who had just gotten married during the Victorian era.

"One of the things the letters revealed was how central a role men played in birth control," Tone says. "Many historians have assumed that women historically have had more expertise in and control over contraception than men, that birth control was part of a separate 'women's sphere' of activity. But men in their letters often show as much, and sometimes more, awareness of fertility control than women.

photo by Stanley Leary

Early 20th century advertisements for contraceptive devices were among the many materials historian Dr. Andrea Tone discovered while writing a new book on the U.S. contraceptive industry. (300-dpi JPEG version - 689k)

"Men have been active in birth control history on a variety of fronts: as supportive lovers, inventors, entrepreneurs, sympathetic doctors, educators, legislators, activists and, of course, as birth control users themselves. Indeed, until the Pill ushered in a new era of medicalized and feminized contraception, the most popular method of birth control in the country was the condom. So, I think there is

room for a more inclusive interpretation of the role of men in contraception," Tone says.

As the Victorian era passed, contraceptives gradually became legalized state by state starting in the early 1920s. But it was a process spanning five decades and even reached the U.S. Supreme Court, Tone says. The high court's decision in Griswold v. Connecticut in 1965 invalidated a Connecticut law banning contraceptives and determined a constitutional right to privacy for married couples. Then the court's 1972 decision in Eisenstadt v. Baird overturned a Massachusetts law banning single people from obtaining contraceptives.

A "big event" that Tone researched for her book was the invention and FDA approval of the birth control pill in 1960; it brought about a revolution in the contraceptive industry and in private decisions. "Women loved the freedom of the Pill, the convenience of uncoupling sex and procreation. You could be on it without thinking about it during intimate relations. Yet some women worried about the Pill's side effects and feared that men would replace their pills with placebos. In their search for a drug-free and cheap method of birth control, they gravitated to intrauterine devices (IUDs). The IUD was sort of like their secret weapon. Men might not even detect it, and they certainly couldn't tamper with it."

Records charting the years preceding FDA approval of the birth control pill also revealed some interesting facts. For example, the FDA approved the Pill in 1957 for treating menstrual irregularities. Apparently, that did not stop 500,000 women from claiming the ailment and getting prescriptions for the Pill. "There were no where near this many women in the population with menstrual disorders," Tone says.

She also reviewed Library of Congress records that include fan mail to Gregory Pincus, one of the Pill's inventors. Many women asked to be his "guinea pigs" during testing of the Pill, despite the risks. And the risks were considerable, Tone says. Early versions of the Pill contained a higher concentration of hormones, making the likelihood of Pill-induced nausea, headaches, weight gain and strokes greater than today.

Though the Pill was originally invented with the lower economic class in mind, it became the favorite contraceptive method of the middle class, Tone says. Meanwhile, IUDs became popular after 1965 as women of all classes sought a simpler, cheaper, drug-free method of birth control. Then, by 1973, when Tone concludes her history, problems arose with the infamous Dalkon shield IUD and others.

The book is the result of six years of research by Tone. It is expected to be published in early 2001, and Tone believes it will find an audience among healthcare policymakers, women's studies scholars, historians and segments of the general public.

"Writing this book revealed to me the timelessness of Americans' desire to control fertility," Tone says, "and how politicized matters of the heart and body have been throughout our past. . . . A lot of the birth control history that has been written has been exclusive to women's history, but the full nuances and complexities of the history of birth control are best captured by an integrative, rather than compartmentalized, approach. This is a story about technology, business, the law, politics, sexuality and medicine."

Tone also hopes more historians will research and write about the history of medical technology, which dates back to ancient times. She is hooked on medical technology history now, she says, and plans to write her next book about the tranquilizer industry during the Cold War era.

For more information, you may contact Dr. Andrea Tone, School of History, Technology and Society, Georgia Institute of Technology, Atlanta, GA 30332-0345. (Telephone: 404-894-7445) (E-mail: andrea.tone@hts.gatech.edu)

ResearchHorizons

Involving the Pilot in Air Traffic Control

How much information is enough to give pilots more involvement in air traffic management?

By Jane M. Sanders

Three jumbo jets are converging on a major airport on different flight paths. Somewhere in between the ground and the sky, air traffic controllers relentlessly dish out commands, knowing those little blips on those little screens represent tons of metal and hundreds of lives.

Pilots follow the directives, sometimes second guessing the air traffic controllers. But they don't know what's on the screen.

What if they did? Perhaps the efficiency of air traffic management would improve.

The technology is available. Called Cockpit Display of Traffic Information (CDTI), it provides an enhanced cockpit display that allows pilots to see other aircraft around them and the distances between them.

But there's a reluctance to fully implement CDTI in commercial aircraft. So far, only low-end versions of CDTI have been installed in commercial aircraft, primarily to help pilots react more quickly in collision avoidance maneuvers.

photo by Stanley Leary

Simulating commercial airline flights, researcher Dr. Amy Pritchett and graduate student L.J. Yankosky are determining the balance needed to give pilots the right information without overwhelming them with too much. Researchers hope their work will lead to the widespread implementation of a technology called Cockpit Display of Traffic Information. (300-dpi JPEG version - 493k)

"There is a reluctance to implement CDTI because of the procedural changes it would require for both air traffic controllers and pilots," says Dr. Amy Pritchett, an assistant professor in the Georgia Tech School of Industrial and Systems Engineering. "But CDTI would allow controllers to give higher types of commands and communicate more directly with the pilots. For example, instead of just telling the pilot what speed to fly, the controller can also tell them what aircraft they will be following in to land and how far behind them to be. This can give the pilot more involvement in air traffic management."

But there is a fine line between giving pilots the right information and overwhelming them with too much. So Pritchett and her students are conducting studies to help set the standard, in hopes that CDTI will be more widely accepted and efficiency improved.

For now, efficiency of air traffic management is compromised for safety. Historically, controllers have put in extra safety margins between approaching and departing aircraft in case one of them exceeds a specified speed. This has resulted in uneven gaps of time between landings and departures. With CDTI getting pilots more involved, controllers could allow aircraft to fly closer together and maintain a consistent pattern of landing and departing planes, making air traffic management more efficient and safer, Pritchett says.

With CDTI in place, air traffic controllers would continue to monitor aircraft, but not have to give navigational commands every couple of minutes. For example, instead of the controller telling the pilot to adjust his speed to a certain value, the controller would tell him or her to stay 10 miles behind the lead aircraft as they approach the airport.

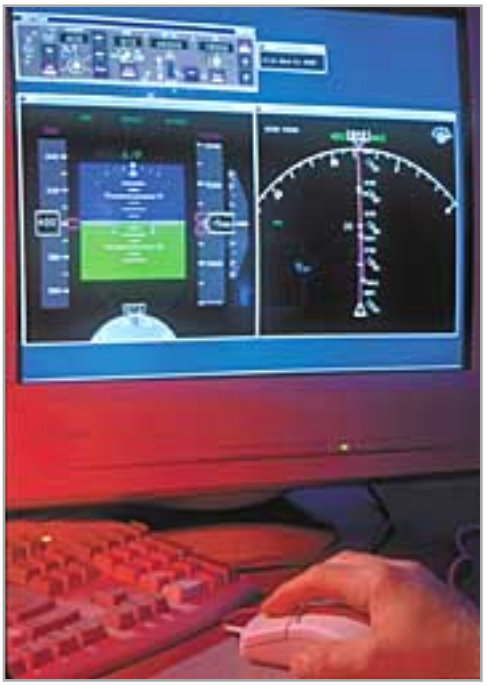
"It's like the difference between the teacher asking a student to write a paper and then letting them do it instead of standing over them while they do it," Pritchett says.

All of this is contingent upon pilots having the right amount of cockpit display information, and that is the focus of Pritchett's current study funded by NASA's Ames Research Center. She and graduate student L.J. Yankosky have modeled and numerically simulated several different air traffic control procedures that would use CDTI. They also conducted flight simulator experiments with 12 commercial airline pilots examining different CDTI implementations. Now, they are analyzing their data. A final report will go to NASA in early 2000, but preliminary results are giving the researchers insight into CDTI's future.

Modeling and simulation studies led the researchers to this hypothesis: Pilots using CDTI must be able to easily assess speeds of surrounding aircraft to safely and efficiently respond to an air traffic controller's higher-level commands (e.g., stay

10 miles behind the lead aircraft).

photo by Stanley Leary



Cockpit Display of Traffic Information technology would provide an enhanced cockpit display that allows pilots to see other aircraft around them and the distances between them. (300-dpi JPEG version - 585k)

The researchers tested their hypothesis with flight simulator experiments involving pilots who ranged in experience from co-pilots on 727s to captains on the newest aircraft types. Pilots flew seven, 15- to 20-minute runs, simulating their arrival at any of four fictitious major metropolitan airports. On the runs, pilots viewed any of three different CDTI displays, offering varying amounts of information. Pritchett posed as the controller, and Yankosky was the co-pilot.

"Pilots had some concerns, depending on how good the display was," Pritchett says. "They liked more detailed information, but with the display presenting the most information, the pilots were concerned that it might be too much. . . . All of the pilots were intrigued by CDTI. But they still want air traffic controllers to be involved -- not to watch them, but to watch what the other guy is doing."

This latter concern resulted, in part, from the pilots' seventh runs, when researchers simulated an "off-nominal" event as two streams of air traffic merged and approached the airport. The "controller" asked the pilot to stay four miles behind the lead aircraft. Meanwhile, the other aircraft slowed 50 knots more than it should have.

"In the display without the information on the other aircraft's speed, it was hard for pilots to react to this situation," Pritchett says. "But they reacted quickly when they had this information."

Pritchett presented the research results in October 1999 at the AIAA/IEEE/SAE Digital Avionics Systems Conference. She hopes the results will assist the Federal Aviation Administration in its decision on when and whether to fully implement CDTI in commercial aircraft. Pritchett believes that approval could come within the next five years.

"Things are ripe for change in air traffic control," Pritchett says. "Equipment is antiquated. There is concern about change. But there must be change because of the equipment and the demand for air transportation."

Pritchett sees the implementation of CDTI in commercial aircraft as an intermediate step in changing technology and air traffic control procedures. Beyond it is the concept of "free flight," which would allow pilots to select their routes based on daily conditions. For now, controllers select routes often based on old airways and without considering conditions, such as winds.

"CDTI is a good intermediary step because air traffic controllers will overall still be in charge," Pritchett says. "They will just be able to give higher-level commands."

In addition to CDTI's potential for improving the efficiency of air traffic management, Pritchett believes its implementation could increase air traffic safety. With CDTI, pilots have a better chance of knowing if air traffic controllers or other pilots might be making mistakes. It could help pilots see a problem forming 10 to 20 minutes before a potential mid-air collision occurs. Still, CDTI is so novel, it will take time to be accepted, Pritchett adds.

For now, CDTI is being tested by the Cargo Airlines Association, which typically involves aircraft flying in off-peak periods and without passengers. CDTI has been used in military aircraft, which are equipped with complementary radar displays, for a number of years.

For more information, you may contact Dr. Amy Pritchett, School of Industrial and Systems Engineering, Georgia Institute of Technology, Atlanta, GA 30332-0205. (Telephone: 404-894-0199) (E-mail: amy.pritchett@isye.gatech.edu)

ResearchHorizons

Connecting the Dots

GTRI helps create new networking standard for defense simulations.

By Gary Goettling

Soldiers and pilots who can train together on networked simulators not only learn how to handle military situations, they develop the teamwork that's essential for a successful mission.

But F-16 pilots operating a simulated mission in an anechoic chamber in Maryland might not be network compatible for a simultaneous mission simulation with an enemy air defense system in Houston and a test control group in New Mexico. Likewise, NATO member nations might have difficulty with allied forces training using various nations' warfighting systems simulations.

The solution is a common, high-level network architecture for an array of simulators widely differing in age, purpose and technological complexity. The U.S. Defense Department began work on this new standard in the mid-1990s under the auspices of the Defense Modeling and Simulation Office and a consortium of government, industry and academic researchers.

Among those involved are Georgia Tech Research Institute (GTRI) engineers, who began supporting the development of the new High Level Architecture standard four years ago. It is challenging work, in part because the development of High Level Architecture (HLA) — a general purpose architecture for simulation reuse and interoperability — is dependent upon a host of ever-changing technologies, says Senior Research Engineer Margaret Loper. She is one of 12 members of the Distributed Simulation Systems (DSS) research team, a part of the Information Technology and Telecommunications Laboratory at GTRI.

Dept. of Defense Visualization Center

U.S. military personnel at Fort Bliss, Texas, work from the Computer Simulation Center, where they were participating in a large-scale air defense exercise. Ensuring interoperability among simulation systems has been the focus of a Georgia Tech Research Institute project.

Distributed simulation is a technology area that has grown increasingly reliable and realistic because of the evolution of all the technologies that go into it, Loper explains.

"You can run very powerful, realistic-looking simulations on a PC, whereas 10 years ago you had to have a very high-end Silicon Graphics machine to be able to do it," Loper says. "So the networking simulations are just one part of the picture. You also have to deal with all the advances in graphics and visual systems, hardware platforms, communication networks, artificial intelligence and behavior modeling. The list goes on and on."

GTRI's responsibilities in the development of technologies that support HLA embrace several major initiatives.

High Level Architecture Testing and Support

GTRI's original role in the HLA project was development of the test process, procedures and tools for determining whether a particular simulation complies with HLA.

A professor from the College of Computing was also assigned the task of designing and documenting time-management services for the HLA interface.

Federation Verification Tool

Another testing project, this effort focuses on testing a group of networked simulations called a federation.

"Once you bring your simulations together and you've got them talking, sending data back and forth using the HLA, how do you verify that all the simulations are really doing what they're supposed to be doing?" says Loper, in framing the task before the GTRI researchers.

Typically, a network of simulators is employed to model a large, complex scenario. The scenario's accuracy depends upon the proper interaction among the individual simulators in the network.

"Each simulation has its own set of rules and responsibilities about what it's supposed to do — whether it's modeling aircraft or tanks, where and when it's supposed to move, what it's supposed to fire at and under what conditions," Loper says. "The federation verification tool runs while the simulations are interacting. It knows what each simulation is responsible for, and it verifies that each one is doing what it is supposed to do. If there's a problem, the tool can pinpoint the simulation that may be causing others problems in the network."

Advanced Simulation Technology Thrust

When it comes to getting simulations to work together, timing is everything. The trick is to develop time-management specifications that eventually will allow synchronization of simulations varying greatly in internal architecture, function and purpose. The specifications would even address the need to track time — some simulations are more time-management reliant than others.

Dr. Richard M. Fujimoto of the Georgia Tech College of Computing accomplished the first part of the task by devising architecture specifications that allow simulations with different needs to share a time-management reference. The project's next phase involves developing the next generation of time-management algorithms that will allow disparate simulations to effectively work together.

High Level Architecture Simulation Interface

With the advent of the HLA, existing simulations can be called legacy systems because they were not designed to operate in the new HLA environment. So GTRI is now developing interfaces, tools and procedures to allow legacy systems to migrate or connect to HLA.

This project has resulted in the development of a software tool, the Distributed Simulation Interface Framework (DSIF), which is being used to migrate simulations to HLA.

MIMI HLA Model Migration

In another project, GTRI researchers have drawn upon their work in HLA to bring an operational legacy simulation into an HLA environment.

Finding a Needle in a Haystack

On-line search tool organizes information into electronic books.

Searching the Web for information can be maddening. Sometimes even the most careful entry of key words into a search engine can return hundreds of hits with no apparent relevance. Imagine the frustration when the search is for information in a highly specialized field such as modeling and simulation.

WebBook is a Georgia Tech Research Institute (GTRI) initiative to build an on-line library of modeling and simulation knowledge. More importantly, its authors are testing new ways to electronically organize information to make online research in other subjects far more productive, as well.

Content and functionality — those are the chief concerns of the WebBook project, says GTRI researcher Andrew Old. He heads a group that has built a WebBook prototype and is working on a production-quality Web site.

"Our goal is to meet a need in the modeling and simulation community for access to comprehensive reference material," he says. "A lot of advanced research information has not been captured in an organized fashion, and even established fundamental concepts are not always easy to find. It's good there's so much information out on the Web, but all that

MIMI, which stands for the Mobilization and Deployment Capability Assurance Project (MADCAP) Integration Management Initiative, is a model used by the U.S. Army Forces Command to plan the mobilization of soldiers for military contingencies. GTRI used the DSIF tool to build a software interface between MIMI and the HLA.

"Now that MIMI supports the HLA standards, the model, which was previously used only in stand-alone mode, can be linked with other DoD simulations for training, analysis or acquisition," says DSS researcher David Roberts.

Human Behavior Modeling and Model-Based Design

One of the new research areas for the DSS group combines its HLA experience with research conducted in Georgia Tech's School of Industrial and Systems Engineering by Dr. Christine Mitchell. DSS researchers are building a model of the decision-making process used by a military squad leader operating in an urban environment. This model will help evaluate the information requirements needed to design computer displays helpful to the soldier. Using HLA, this model of the soldier can be integrated with other simulations to evaluate requirements in a realistic simulated environment in real-world military exercises.

"This project is a good example of how the HLA can make a difference," Roberts explains. "Simulations that were developed for different reasons can now be brought together into one environment for training and new concept development."

> **For more information** on the Distributed Simulations Systems group and their HLA research, point your Web browser to http://dss.gtri.gatech.edu. You may also contact Margaret Loper, Information Technology and Telecommunications Laboratory, Georgia Tech Research Institute, Atlanta, GA 30332-0832. (Telephone: 404-894-4663) (E-mail: margaret.loper@gtri.gatech.edu); or David Roberts at the same address. (Telephone: 404-894-3135) (E-mail: david.roberts@gtri.gatech.edu)

information also makes it difficult to find specific answers."

Old and his team elected to build a database-driven Web site to store all the modeling and simulation material they could gather. The site is interactive in that experts can submit information to fill gaps in the overall body of information, and they can add new research reports to the database.

The tricky part is figuring out a way to organize and index the information so it's readily accessible to experts and non-experts alike. To start, WebBook data is divided into text blocks or articles of up to 2,000 words each. Each article is defined by a set of attributes or keywords linked explicitly to other articles with the same keywords. Or articles can be linked implicitly by keywords that are similar or related, but not exactly the same.

WebBook users enter the appropriate terms into a search engine that selects matching articles and presents them as an electronic book.

"Articles can be organized in a different ways to create these taxonomies or books that can be geared to different types of users," Old says. "So, for example, if you're new to the world of modeling and simulation, there's a book geared toward you with the basic concepts you need to know.

"A lot of times, people don't quite know what to search for specifically," Old adds. "If we can present these articles as a book, then they don't necessarily need to know — they can just browse through the book."

The implicit article links will help users narrow or broaden their searches without starting over. "They give the user the ability to navigate to another article or find out about the existence of that article even if they're not in the same book," he says.

In addition, WebBook gives users the option of selecting additional articles on a subject in either greater or lesser detail, depending on the specificity of their needs.

Although WebBook will be devoted to modeling and simulation, its methodology could be widely applied.

"You can plug in any type of content to serve any community you want," Old says. "The basic idea is simple: It's getting the right information to people in the easiest format possible."

For more information, you may contact Andrew Old, Information Technology and Telecommunications Laboratory, Georgia Tech Research Institute, Atlanta, GA 30332-0800. (Telephone: 404-894-7256) (E-mail: andrew.old@gtri.gatech.edu)

— Gary Goettling

ResearchHorizons

Designing with Humans in Mind

Internet-based design tools will aid traffic management center planners in minimizing potential for operator error.

By Jane M. Sanders

Days are hectic in the traffic management centers of most major U.S. cities. Operators are busy monitoring highway remote cameras, analyzing road sensor data and talking to motorists reporting traffic incidents. In the face of such overwhelming amounts of information, human errors can occur.

But when traffic management centers (TMCs) are designed with human capabilities in mind, these errors can be minimized. TMC designers now have an easier time of accomplishing this task because of a new central repository of information available via the Internet.

photo by Stanley Leary

Traffic management centers around the nation have learned many lessons in human factors design, and some of their questions have been answered by GTRI's TMC simulator studies, ongoing since the early 1990s. (300-dpi JPEG version - 1.04MB)

Researchers at the Georgia Tech Research Institute (GTRI) have created a Computer-Aided Design Support System (CADSS) that provides a complete set of tools for TMC designers who consider human factors in the design process.

"This project provides an innovative way of getting the information out," says Dr. Dennis Folds, a principal research scientist at GTRI. "One of the key challenges of any research activity is to get the results

in the hands of those who will use the results. Neither Georgia Tech nor the Federal Highway Administration (FHWA, which is funding the project with the U.S. Department of Transportation) were satisfied with just having books on a shelf. We wanted something that could be more easily infused into the design process."

The interactive tools designed by Folds' research team include: the Design Guidelines Tool; Design Dialog Tool; Case Studies Database Tool; and the Report Generation Tool.

The Design Guidelines Tool is an online human factors design handbook researchers completed in a previous project for FHWA. The computer-based version adds features for searching, indexing, getting help and obtaining other references. "This tool helps designers easily find the guidelines that are relevant to whatever they are doing," Folds explains.

The interactive Design Dialog Tool allows users to start with a blank sheet of paper and go through the human factors design process. "We are helping designers decide on the amount of floor space operators need, what kind of workstations they might use, how those workstations should be laid out, the kind of hardware interfaces and what kinds of software they will need," Folds says. "At every appropriate question, users can see relevant guidelines from the handbook, access tutorials to better understand the decisions they're considering and get additional references."

The Case Studies Database helps users find good examples of human factors practices. "An example is a good way to learn," Folds says. The database was compiled with input from design engineers. Users can select from a variety of example categories, including control room layout, hardware, workstations, software systems and TMC operator responsibilities. The database includes real-life TMC examples and also best practices information from TMC simulator studies at GTRI. Information includes photos and videos from these TMCs.

A GTRI research team has created a set of interactive tools for designing Traffic Management Centers with human capabilities in mind. They are the Design Guidelines Tool, Design Dialog Tool, Case Studies Database Tool and the Report Generation Tool. (Click on image to see larger 79k version).

The Report Generation Tool provides a way for design engineers to document what they find or determine. A report might include specifications for procurement, guidelines to pass on to a software company and documentation of a good example. "This tool helps users create a tailored output for use in

other parts of the design process," Folds explains.

All of the tools have been prototyped, evaluated and are undergoing continued development. Designers can easily update the databases as knowledge evolves because the tools are an Internet-based resource accessible with any Web browser.

The information is timely as plans are being made to upgrade many existing major metropolitan TMCs to put them in the class of Intelligent Transportation Systems (ITS), Folds says. (ITS involves the use of sensors and high tech communications technology to make transportation more efficient.) Also, the CADSS will be helpful to designers as many new TMCs are on the drawing board. All major U.S. cities have or are about to have TMCs. And in five to 15 years, all medium-sized U.S. cities will have them, Folds predicts.

Examples of new, ITS-class TMCs are in Atlanta, Phoenix and San Antonio, Folds says. "As these were designed, engineers began to understand why they had to strongly consider human factors in design," he adds. These TMCs have learned many lessons in human factors design, and some of their questions have been answered by GTRI's TMC simulator studies, ongoing since the early 1990s.

These studies provided some of the content for a TMC human factors design handbook and technical report, which in turn provided some of the content for Folds' CADSS tools.

"We believe this will be a good set of tools if designers have reasons to give priority to human factors considerations," Folds says. This emphasis varies among states and municipalities.

"Considering human factors in design saves money and creates a better product," Folds says. "It provides for better operation. There's often no second round of development to correct problems. You come closer to getting it right the first time. You avoid many of the errors and perhaps training requirements that are encountered with a non-human-factored design."

For more information, you may contact Dennis Folds, Electronic Systems Laboratory, Georgia Tech Research Institute, Atlanta, GA 30332-0840. (Telephone: 404-894-7262) (E-mail: dennis.folds@gtri.gatech.edu)

ResearchHorizons

Better than Human Flight Control Systems

Re-engineered neural networks are dramatically changing adaptive control of aircraft.

By Rick Robinson

It's reassuring to know the jetliner you're boarding is equipped with numerous automatic systems, which support the big machine itself as well the pilots that fly it. Such systems allow the plane to fly unattended at times, and they kick in quickly if a wind blast should upset the airplane or the pilot should fly too close to the terrain or other traffic.

But who, or what, is watching the automatic systems? What happens if an automatic system, or any of the vital flight surfaces controlled by such systems, alters or fails at a critical moment, requiring major adjustments throughout the plane's flight-control system?

photo by Stanley Leary

In the future, the answer may be "don't worry, the neural network will take care of it." Much like the human brain, artificial neural networks consist of collections of processing elements that are highly interconnected. Each collection transforms a set of inputs to a set of desired outputs.

Artificial neural networks, already used for such applications as pattern recognition and process control, are being re-engineered by Georgia Institute of Technology scientists. The redesigned networks will perform a host of monitoring and adjustment functions in aircraft

— what those in the field call "adaptive control."

Artificial neural networks, already used for such applications as pattern recognition and process control, are being re-engineered by Georgia Tech scientists led by Dr. Anthony Calise (right). Redesigned networks will perform a host of monitoring and adjustment functions in aircraft — what those in the field call "adaptive control." (300-dpi JPEG version - 629k)

"We're pursuing adaptive control using neural networks on a whole spectrum of aircraft," says Dr. Anthony J. Calise, professor of aerospace engineering at Georgia Tech. Calise and his colleagues are engaged in seven aircraft-related, neural-network projects, funded variously by NASA, the Air Force, industry sponsors and Georgia Tech. Fighter and tiltrotor aircraft, which can be tricky to control and need complex flight-control systems, have been the first candidates fitted with neural networks. But commercial aircraft such as jetliners are likely to benefit, too, Calise says, as are guided missiles, guided munitions and almost anything else that flies.

Meanwhile, some of these projects are already well advanced. Calise, his colleague Dr. J. V.R. Prasad and their Georgia Tech research team — working closely with Boeing Phantom Works — installed a neural network onboard an experimental aircraft, the X-36, a one-fifth-size unmanned jet research aircraft that simulates conditions on a full-size vehicle. The X-36, developed under NASA auspices by Boeing, was tested recently at Edwards Air Force Base, and its neural network functioned quite successfully, Calise says. But the tests had to be cut short because of hardware problems.

And in Georgia Tech's Uninhabited Aerial Vehicle Lab, Calise, post-doctoral researcher Dr. Rolf Rysdyk and a team of graduate research assistants are working with Guided Systems Technology Inc. to test a neural network installed in a remotely piloted helicopter.

Similar, But Better

For obvious safety reasons, all modern aircraft have redundant controls — backup controls in case a primary control conks out, Calise explains. But redundancy alone can't compensate automatically for a major system loss; pilots must be trained to manually compensate if, for instance, an engine should sputter or a rudder fail. During such an emergency, the pilot must explore the remaining controls and learn what actions will restore control. In essence, the pilot is swiftly retraining himself or herself to fly a degraded vehicle.

This process of pilot recovery is made more tricky by the complexities of modern flight control systems. Many of today's aircraft, including military jets, have intrinsically unstable designs and cannot be flown without so-called "feedback systems" — highly sophisticated flight control systems that can sense aircraft performance and angular rates and then feed back a corrective signal that automatically helps stabilize the vehicle.

Neural networks may be able to dramatically alter this process. By focusing on two main areas — how a vehicle flies and the potential failure scenarios for that vehicle — researchers are trying to train the neural network to deal with any system failure.

"A neural network is working all the time," Calise says. "When something goes wrong, it adapts just like a human being might adapt to a failure." But, he adds, with one potentially crucial difference: The neural network has the potential to deal with failure more quickly and accurately than any human pilot.

In fact, ideally the recovery process would happen so rapidly it would be virtually transparent to the pilot. A failure would occur, perhaps accompanied by minor airframe bumps, but the plane would continue to fly and respond to commands normally. In the critical first few seconds after the failure, the pilot would probably know something had happened, but not what. Only when detailed reports began to filter in would the nature of the failure become clear.

The neural network system is sufficiently sophisticated that it can even deal with damage to the airframe, Calise says. "The neural network is there to maintain the handling qualities of a well-functioning flight control system — even if you get part of a wing shot off, which is just one of the failures we've mimicked in simulation."

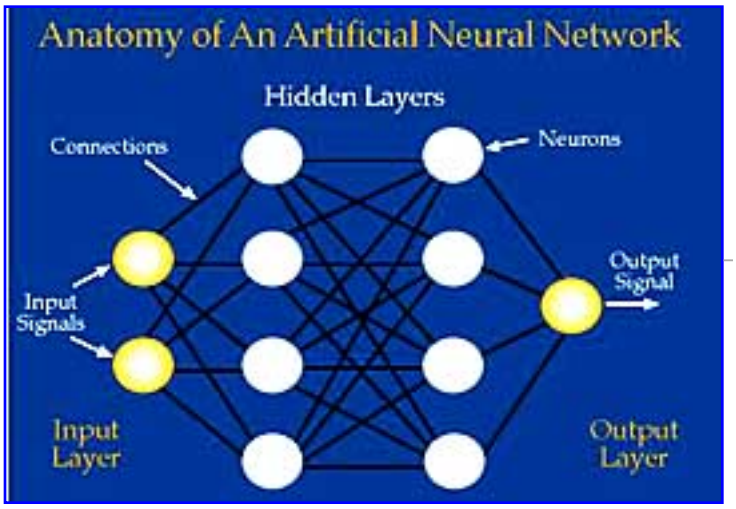
Imitating the Brain

Neural networks essentially consist of an algorithm — basically a computer code. In an aircraft-based system, the neural-network algorithm becomes part of, and works cooperatively with, the flight control system computer. Like other software, such algorithms have to be tested and refined until they do the job right. As Calise puts it: "The key to using a neural network is to be able to develop efficient algorithms for training neural networks." A neural network tries, in so far as possible, to mimic human brain function, Calise explains. The brain's active ingredients, so to speak, are its neurons, an interconnected biological system in which each neuron has mechanisms for receiving and sending signals to other neurons.

Neural networks, too, have "neurons" that receive signals from other neurons, process them and then output a signal. These "neurons" are units of computer code that are mathematical representations of a human neuron's input-output functions. They are linked together by connections called "weights"; changes in these

"weights" allow the network to learn by recognizing patterns or configurations.

One well-known approach to neural network training involves "back propagation," used for such applications as pattern recognition. In back propagation, the system is programmed to learn from its errors; repeated exposure to different objects and patterns is combined with retraining of the weights whenever there is a mistake. This approach is analogous to the human experience of avoiding the same mistake, thus learning from experience.



Neural neworks are typically organized in layers. Layers are made up of a number of interconnected "nodes" that contain an "activation function." Patterns are presented to the network via the "input layer," which communicates to one or more "hidden layers" where the actual processing is done via a system of weighted "connections." The hidden layers then link to an "output layer" where the answer is output as shown in this graphic. (Click on the image to see larger 38k version).

But back propagation involves many computations and experiments, Calise notes. Much of the work is done off line in a tedious, time-consuming process, then put on line when the system works correctly.

"In flight control we don't have that luxury," Calise says. Such a system must learn on line in real time as it is exposed to new environments - and be ready to deal with unpredictable failures.

To train aircraft networks in real time, the Georgia Tech team has had to bring new tools to bear. Even formulations used in other cutting-edge neural network research, such as robotics applications and automation, don't apply to aircraft neural networks.

A Software Add-on

Rather than strip out existing flight control software and replace it with a new system, the Georgia Tech scientists chose to insert the neural network into existing flight control systems. Thus the network becomes an addition to, rather than a replacement for, an existing flight control system.

"That ability, to add on rather than replace, has been a key to our being able to get to where we are today," Calise says. This integration of neural network function with flight control promises to improve aircraft design and testing, along with enhancing flight and flight safety.

Today, flight control systems are designed for many different operating conditions. As an aircraft moves from one operating condition to another, a flight control system must be adjusted to compensate — a process called "gain scheduling." In today's digital flight control systems, which are implemented in the form of computer code, "gain" means multiplication of an error signal by a number. Gains are varied, either automatically or manually, for speed, altitude, dynamic pressure, payload and numerous other factors.

Designing a sound gain schedule for a given aircraft is laborious and expensive. Extensive wind tunnel and other tests are necessary to gather data, followed by demonstration of the gain schedule in flight.

Neural networks can alter the entire process by simply removing gain-schedule design, Calise says. Instead, scheduling is done automatically in real time. The neural-networked controller adapts as it flies, automatically rescheduling itself to current flight conditions. For instance, changes in the aircraft's load would not require rescheduling the controller; rather, the neural network would automatically learn the shift in the centers of gravity and the system would reconfigure itself.

The result: top in-flight performance along with big savings in flight control system engineering costs.

Calise sums up: "Even in the absence of a failure, we gain large advantages from using a learning system because it can adapt to configuration changes transparently."

Tiltrotor aircraft offer a good example of the advantages of automatic gain scheduling. Such a vehicle flies like both a helicopter and a conventional aircraft, demanding a highly complex flight control system.

"We've demonstrated that without scheduling and with a single set of gains — and with the neural network present in the flight control system — we're able to fly the aircraft throughout its flight envelope," he says. "We can go through hover, transition, forward flight, different altitudes, different airspeeds and maintain even better performance than the gain-scheduled flight control system does."

Under Calise's direction, Rysdyk is working on a neural network that functions on a civilian tiltrotor aircraft.The research team performed a piloted full-motion flight simulation test of this flight control system at the NASA Ames Research Center last spring.

Guided munitions is another area with many different configurations and designs. Each munition type has to be wind tunnel tested as part of its autopilot design, an expensive process. Neural networks hold out the promise of a single bolt-on tail assembly that could

fly, guide and stabilize an entire munitions class better than conventional autopilot designs — and do so without the need of extensive wind tunnel testing.

A Profitable Sabbatical

Calise likes to stress the roots of his team's impressive project roster. The seven current projects can be traced back to a 1990 sabbatical that Calise was able to spend at Drexel University in Philadelphia, Pa. (an institution where he himself once taught). Taking a needed break after 15 straight years of teaching gave him time to pursue full-time research into neural networks, working with a colleague in the signal processing and image processing areas.

"That research led to a very productive effort in the control area" that in turn led to the current crop of adaptive control projects, he says. "It was a fruitful sabbatical."

Ultimately, he says, neural network development may even allow a one-size-fits-all approach throughout entire aviation areas. A flight control system for one aircraft could be moved to a different aircraft type, and it would reschedule for that vehicle automatically.

"That's kind of like the dream of adaptive control — to be able to do something like that," Calise says. "And I think we're very close to realizing that dream."

- **For more information** on Georgia Tech neural network research, visit this Web site: www.ae.gatech.edu/research/controls/
- There are many good Internet sites containing reference reading on neural networks. See for example: www-dse.doc.ic.ac.uk/~nd/surprise_96/journal/vol2/cs11/article2.html blizzard.gis.uiuc.edu/htmldocs/Neural/neural.html.
- You may contact Dr. Calise at School of Aerospace Engineering, Georgia Tech, Atlanta, GA, 30332-0150. (Telephone: 404-894-7145) (E-mail: anthony.calise@aerospace.gatech.edu)

ResearchHorizons

Pulp Non-Fiction

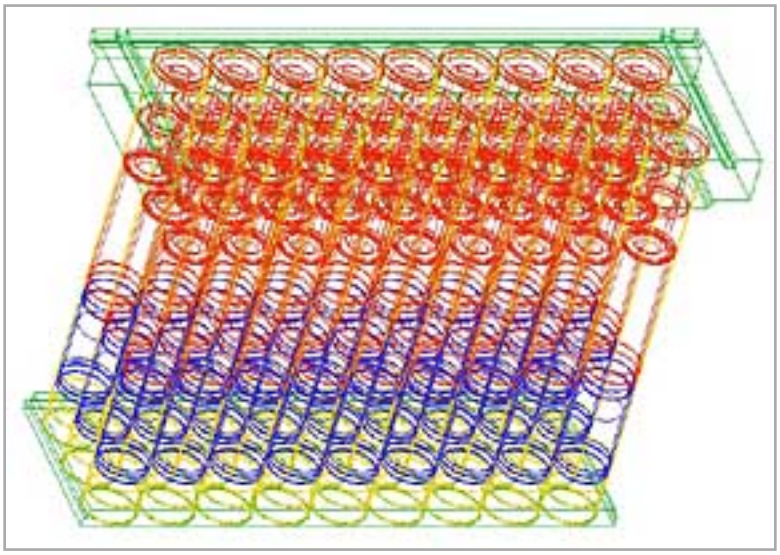
New papermaking technology truly means less is more.

By T.J. Becker

A new technology being commercialized by an Atlanta company yields stronger paper, while using less fiber and energy, translating into lower costs for paper manufacturers and good news for the environment.

The technology applies to the heart of papermaking — formation of the fiber network. It was invented by Dr. Cyrus Aidun, professor of fluid dynamics at the Institute of Paper Science and Technology (IPST) and adjunct professor at the Georgia Institute of Technology's School of Mechanical Engineering.

courtesy of Dr. Cyrus Aidun



A new technology is strengthening paper fiber, while lowering the energy costs of manufacturing it. A device that is retrofitted into an existing paper machine's headbox (shown here) disperses wood fibers uniformly in all directions, strengthening the paper. (300-dpi JPEG version - 546k)

When paper products are made, wood fibers are first suspended in water, then drained and applied on moving screens to be pressed and dried. Because of the hydrodynamic characteristics inherent in the production process, fibers tend to orient in the direction of the machine, rather than spreading uniformly.

The result is an irregular network of fibers that has been an industry problem since high-speed paper machines were introduced more than 40 years ago. An irregular fiber network

causes paper to curl, instigating paper jams in photocopiers and laser printers. Also, paper remains weak in the cross-machine direction, which is why it's easy to tear an article from a broadsheet newspaper lengthwise, but not horizontally. Though this may not matter to newspaper readers, strength is a crucial issue in the packaging arena, where cardboard and corrugated products must measure up to designated standards.

Aidun's invention is a redesign of the flow mechanism in the fiber network-forming process and represents several years of research and development. He spent considerable time studying the fluid dynamics of the fiber-forming process and learning why fibers orient toward the direction of the machine.

"Once we understood the physics, we then altered the hydrodynamics by introducing the correct vorticity field to disperse fibers uniformly in all directions," says Aidun, explaining that vorticity is the circulation of fluid elements around an axis.

Aidun achieved the desired vorticity field with a device that is retrofitted into an existing paper machine's headbox. The device comes in three forms — mechanical, electromagnetic and ultrasonic.

By increasing the uniformity of the fiber network structure, Aidun's VORTIGEN™ System results in two major benefits: (1) Paper products become stronger and more uniform; and (2) tremendous savings are realized in raw materials. That extends not only to fiber, but water, energy and additives used in pulp and papermaking processes.

"This technology will rank among the top advances in the papermaking industry over the last 25 years and should continue to be cutting-edge well into the 21st century," says E. J. "Woody" Rice, vice president of IPST. A graduate research university based in Atlanta, IPST is a global leader in pulp and papermaking research and maintains a research alliance with Georgia Tech.

"This could really change the properties of all grades of papers and should lead to wide range of new development in converting and packaging design," Rice adds.

Although the VORTIGEN technology applies to a wide range of paper products — from lightweight tissue to heavyweight grades — researchers are focusing initial commercialization efforts on the packaging arena. It is the largest segment of U.S. papermaking in terms of volume production.

Aidun already has conducted pilot tests with a small-scale model of the mechanical device. On average, this model yielded a 10 percent increase in strength and a 10 percent decrease in raw materials for packaging products machines.

With the average machine using 250,000 tons of fiber each year, VORTIGEN is expected to decrease fiber consumption by 25,000 tons — translating into an annual savings of several million dollars per machine. What's more, companies would also save in energy use and water consumption.

"An enormous amount of water is used in pulp processing (200 or more parts water for every one part fiber)," Aidun says. "Considering that there are more than 8,500 paper machines in the world, and that the paper industry is the second largest industrial consumer of energy, the savings in energy consumption and the environmental impact would be significant. The industry will invest to broadly implement the technology because it will pay for itself in a few months."

Commercialization efforts are under way already. In 1998, IPST granted an exclusive worldwide license of the technology to Fluidix Microforming Systems, a start-up company housed in the Advanced Technology Development Center (ATDC), Georgia Tech's incubator for fledgling firms with a high tech focus. Aidun is president of Fluidix with Diane Murdock, a paper industry veteran, serving as vice-president.

A full-scale commercial version of the mechanical device is being constructed by Fluidix through a project funded by a consortium of 30 paper companies. Aidun expects it to be in operation early this year in a Florence, S.C., plant owned by Smurfit-Stone Co., the world's largest manufacturer of packaging products.

Still in development through a U.S. Department of Energy-funded project are electromagnetic and ultrasonic-controlled devices, which should be ready for pilot tests within the next year or two with commercialization occurring within five years.

"The mechanical device is very appealing to the industry because it is simple to install and operate," Aidun says. "Yet I consider the field-controlled devices (electromagnetic and ultrasonic) will be the ultimate systems to be used because they offer superior control and on-line profiling capabilities."

"Fiber is a huge issue for the paper industry," Murdock says. Not only is the cost of fiber at stake, but supply is also a global concern, she explains: "People in the industry are extremely excited about the opportunities this new technology represents for their companies."

For more information, contact Dr. Cyrus Aidun, Institute of Paper Science and Technology, Atlanta, GA, 30332-0620 (Telephone: 404-894-6645) (E-mail: cyrus.aidun@ipst.gatech.edu)

Send questions and comments regarding these pages to Webmaster@gtri.gatech.edu

Last updated: February 10, 2000

ResearchHorizons

Pandamonium

Tech partners with Zoo Atlanta to help preserve pandas.

By Amanda Hainsworth

The long-awaited arrival last fall of the two giant pandas at Zoo Atlanta ensures the continuation of unique research that aims to help save this very rare endangered animal. The Georgia Institute of Technology, in partnership with Zoo Atlanta, is taking a behavioral research approach on how to improve the success rate of captive panda breeding.

Rebecca Snyder, a doctoral student from the Georgia Tech College of Sciences, has been researching the behavioral development of pandas at southwestern China's Chengdu Zoo and Chengdu Research Base of Giant Panda Breeding for the past two and a half years. Snyder believes the tendency of Chinese researchers to remove panda cubs from their mothers before six months of age cuts off the cubs from important maternal interaction and guidance.

photo by Caroline Joe

Giant Pandas arrived in Atlanta in the fall of 1999.

"In Chinese zoos, the cubs have usually been weaned by six months of age so that the mother can become pregnant and produce another cub as soon as possible," she says. "In the wild, cubs stay with their mothers for 18 months, sometimes longer."

Snyder sees this mother-cub relationship as the key to the panda cub's behavioral development and, ultimately, to the likelihood of it

breeding successfully.

"The mother-cub relationship is the most important one a panda will have," Synder says. "Possibly because captive pandas are separated so early from their mothers, they don't have the opportunity to learn important social behaviors.

"Even though pandas are solitary as adults, they still need to know how to react to other pandas if they are to mate and then, if female, how to look after a cub," she adds.

Lun Lun and Yang Yang, the two cubs that arrived at Zoo Atlanta, have been the subject of Snyder's watchful eye since their birth at Chengdu Research Base of Giant Panda Breeding. Yang Yang stayed with his mother for 13 months, while Lun Lun stayed with hers for four and a half months. They were born within three weeks of each other and are now more than two and a half years old.

At Zoo Atlanta, Snyder continues to study their behavioral differences and development in the Georgia Tech Laboratory for Animal Behavior Research. She is also investigating their transition to puberty and adulthood, along with their reproductive behavior.

Chengdu researchers are uncertain how closely related Lun Lun and Yang Yang are, and because of that, it is uncertain whether they will breed, Synder explains.

Snyder's research is being overseen by Dr. Terry L. Maple, director of Zoo Atlanta, and professor of psychology and the Elizabeth Smithgall-Watts Chair of Behavior and Conservation at Georgia Tech.

For more information, see www.zooatlanta.org.

ResearchHorizons

Faculty Profile: Amy Bruckman

Educational software designer believes in learning it by doing it.

By Jane M. Sanders

How many times have you heard your children — or someone's children — ask why they had to learn a certain fact or process in school? They saw no application of that knowledge to the real world.

Amy Bruckman has heard that question, too. And she has a way to put an end to it. It's a fancy-sounding concept called "constructionism," but the premise is really quite simple.

"Part of the theory is that kids learn better when they know why they're doing what they're doing," explains Bruckman, an educational software designer and assistant professor in the Georgia Institute of Technology's College of Computing. "If you tell them, 'Here, learn this equation,' they're going to moan. So you tell them let's make a robot car that explores the room itself and then hides in the shadows. And the kid says, 'But I don't understand how to make it navigate.' Then you teach that same equation in the context of getting the robot to work. Now the kid wants to know that information, and they learn it in a very different way."

photo by Gary Meek

Dr. Amy Bruckman and Ph.D. student Josh Berman created The Turing Game to explore on-line identity. Since its on-line posting last summer, The Turing Game has attracted more than 8,000 players from all seven continents. (300-dpi JPEG version - 549k)

Constructionism, which is widely employed in technology and communication education, deals with motivation for learning at the individual level. Bruckman takes the concept further with the power of the Internet.

"My work adds a new emphasis on the social aspects of learning," Bruckman says. "Maybe part of the reason you're making the robot car in the first place is to show off to your friends. People don't construct things in isolation. And the strength of the Internet is in giving a supportive, community context for learning and construction."

Bruckman's research career — young though it is — already is filled with numerous projects built on her confident commitment to collaborative learning via virtual communities she creates on the Internet.

A World of Words

While still a graduate student at the Massachusetts Institute of Technology, Bruckman created one of her first Internet-based virtual communities as her doctoral dissertation project.

In 1995, Bruckman and the MIT Media Lab officially launched MOOSE Crossing, a text-based virtual community for children ages 8 to 12. There, they join with a parent's written permission, download Bruckman's MacMOOSE or WinMOOSE client program to connect to the MOOSE Crossing server via an Internet connection. In the virtual community, children construct games and get to know other kids from around the world. Meanwhile, they learn reading, writing and computer programming. Children help each other and have fun creating imaginative characters and scenarios.

"You could build a swamp next to the forest, a pet store in town, or maybe a disco in The Emerald City," Bruckman says. "You could make an elephant that tells elephant jokes, or a robot that asks people what they think about nuclear power. The world of MOOSE Crossing is built of words by kids, for kids. Big people are welcome too — especially teachers looking for interesting activities for their classes."

MOOSE Crossing, now based at Georgia Tech at www.cc.gatech.edu/~asb/moose-crossing, has been a success with pre-teens and teens. About 300 children are active participants now, and several teachers use MOOSE Crossing in their classrooms. Many children have improved their writing skills, teachers report, and made a lot of new friends.

Now, A Graphical World

With MOOSE Crossing operating smoothly, Bruckman and students Elizabeth Edwards, Jason Elliott and Stuart Jeff took on a new challenge a year ago — creating an intellectually engaging, graphical virtual world. This long-term project, called AquaMOOSE 3D because of its underwater theme, is funded by Intel Corporation and the

National Science Foundation.

Like MOOSE Crossing, it is a multi-user game construction kit for use in a shared on-line environment. But this one operates in a three-dimensional graphical format. It targets middle and high school students who will learn by programming their own video games.

"AquaMOOSE makes different learning ideas salient," Bruckman says. "It is more oriented to math and art, and computer programming is a common theme through both game construction kits. So it's good for different learning goals and appeals to different kids."

photo by Stanley Leary

As an assistant professor in the College of Computing, Bruckman supervises and collaborates with doctoral degree students in their research projects. True to her "constructionist" philosophy, Bruckman thoroughly enjoys the interaction, she says. (300-dpi JPEG version - 492k)

There are a lot of design challenges in creating a graphical virtual world that is truly educational, Bruckman says. "We're still in the fairly early stages, but I think we've come a long way in revising the design to make it more fun," she adds. "Still, we've got a lot of engineering to do to make it possible."

When AquaMOOSE is completed, Bruckman will distribute it free of charge, just as she did with the MOOSE Crossing software. Field testing will begin in 2000 on AquaMOOSE.

History Repeats Itself

As an assistant professor, Bruckman supervises and collaborates with doctoral degree students in their research projects. True to her "constructionist" philosophy, Bruckman thoroughly enjoys the interaction, she says.

One project that excites her is student Jason Ellis' development of on-line oral histories, involving stories ranging from World War II veterans to African-Americans who lived through the civil rights era. This work involves senior adults communicating online from the Atlanta area and across the country.

The project is tentatively titled American Timewarp and is funded by IBM. In the past

year, Ellis has done pilot work in an inner city Atlanta middle school, with students interviewing senior citizens using e-mail and then developing oral histories. Some of the seniors live in a nearby government-subsidized housing project; researchers found others online. Bringing the students and seniors together makes sense, Bruckman asserts. The problem is logistical.

"It takes a tremendous amount of energy to pull off a visit between students and seniors, and most teachers are already overwhelmed with work," Bruckman says. "Our model starts with literature — in one case a short story called 'The Golden Cadillac.' The kids generate questions based on the literature and ask the seniors questions online during the school year."

Ellis is using the lessons learned in this fieldwork to build an online community that will facilitate the development of on-line oral histories. In this community, students will put what they've learned into a Web resource to share with students from other schools, online senior adults and the public. The online community will be open in late 2000. For more information on the project, see www.cc.gatech.edu/elc/at/.

Identity Questions

Another fun project had Bruckman and student Joshua Berman designing "The Turing Game." It is based on a test of artificial intelligence called a "Turing Test." The goal was to write a computer program so good that people could not distinguish its intuitiveness from a human's.

But "The Turing Game" is more closely aligned with the original idea of the Turing Test, Bruckman explains. It was intended to see if a person could distinguish the differences between men and women without being able to see them — basically doing it with written responses.

"The Turing Game is kind of like that old game show called 'To Tell the Truth,' " Bruckman says. "You have a panel of people with all but one of them pretending to be something they are not. The audience asks questions via the computer, trying to determine which panelist is telling the truth."

Online players have been trying out The Turing Game recently with questions designed to reveal a panelist's gender. Here's a sample Q & A from

people trying to portray women: "What's your best beauty tip? Nicky says: Mix your own concealer with Oxy10. It's a better color than the one that comes out of the bottle. Rhonda says: Always blot your lipstick with a piece of tissue." Who was really a woman? Nicky.

Dr. Amy Bruckman is creating an intellectually engaging, graphical virtual world called AquaMOOSE 3D. It is a multi-user game construction kit for use in a shared on-line environment. AquaMOOSE3D targets middle and high school students who will learn by programming their own video games. (300-dpi JPEG version - 344k)

At the heart of this research project is the issue of on-line identity, Bruckman explains. "How is it different interacting just through text with people of different ages, races, genders? The point of the game is a participatory philosophical exploration of on-line identity," she says.

Since its posting on the Web in July 1999, The Turing Game has attracted more than 8,000 players from all seven continents. They have played more than 1,000 games, mostly on gender, but also on race, religion and age, among other topics. Participants play via an Internet-based virtual community at www.cc.gatech.edu/elc/turing. The project is funded by Microsoft.

Other Issues to Explore

Bruckman's research is filled with socio-political questions. In another project, she is investigating the management of deviant behavior online with graduate student Priscilla Dodds.

"There are some deep issues here of power and control," Bruckman says. "And as these on-line communities become a bigger part of our lives, there are real questions about who makes the decisions. Do people have rights? It's complicated.... Democracy is time consuming. We do it in the real world because it's worth it. But is it important enough in the on-line world? Maybe not."

Bruckman also wants to know the effects on individuals of community support derived on line. Many people fear that the virtual world is replacing the real world for active Internet users, but Bruckman's research shows this is not true.

"What we found uniformly is that people who were completely absorbed with the on-line world to the exclusion of the real world were people with serious pre-existing personal problems," Bruckman says of research she did several years ago with psychologist Sherry Turkle. "It is not the case that someone who had a balanced life was exposed to the technology and then went off the deep end."

On the positive side, the community support found in a virtual community can provide

students with a lot of help, Bruckman says. "Community support from the virtual world is certainly a powerful tool we could learn to use more effectively," Bruckman says. "The Internet has the potential to facilitate that."

For her part, Bruckman will continue her quest to harness the Internet's power to educate and enrich.

For more information, you may contact Dr. Amy Bruckman, College of Computing, Georgia Institute of Technology, Atlanta, GA, 30332-0280. (Telephone: 404-894-9222) (E-mail: amy.bruckman@cc.gatech.edu) More information is also available at www.cc.gatech.edu/elc.

Research Horizons

Research Notes

Food Safety

Biosensor that detects pathogens in poultry and other foods being tested in in metro Atlanta processing plant.

Recent incidences of contaminated meat in grocery stores and restaurants have heightened consumer concern. But people who eat meat may rest easier if a new bacterial-sensing device being field tested this winter delivers the accurate and speedy results, plus the low costs its developers predict.

The device, called a biosensor, was developed at the Georgia Tech Research Institute (GTRI). It can simultaneously identify species and determine concentrations of multiple pathogens — including the deadly E. coli 0157:H7 and Salmonella — in food products in less than two hours while operating on a processing plant floor.

"The most significant advantage of the biosensor is the time reduction in assessing the presence of contamination," says Nile Hartman, a biosensor developer and senior research engineer at GTRI.

photo by Gary Meek

Results from a field test at a metro Atlanta poultry plant will help researchers, including Dr. Paul Edmonds, right, further refine the biosensor technology before commercialization.

Lab tests for E. coli and Salmonella in meat are required by federal regulators, but there are no standards for bacterial concentration. Most companies perform laboratory tests, but they are costly and slow — sometimes not even yielding results for 48 to 72 hours. That delay requires that food products remain stored in warehouses for longer periods.

"The biosensor will help in overall quality control in food processing plants," says collaborator Dr. Paul Edmonds, a professor of biology at Georgia Tech. "It would minimize the chance of the final product being contaminated."

Georgia Tech researchers — in collaboration with Dr. Robert Brackett, a professor at the University of Georgia's Center for Food Safety and Quality Enhancement in Griffin, Ga. — have been developing and testing the biosensor in their laboratories for about four years. Recently, they began a field test at Gold Kist in Carrollton, Ga., just west of Atlanta.

Laboratory tests have proven the biosensor is extremely sensitive, meaning it can detect pathogens at minute levels of 500 cells per milliliter. Researchers believe they can improve that sensitivity to 100 cells per milliliter. Current laboratory methods only achieve sensitivity levels of 5,000 cells per milliliter, and they usually take from eight to 24 hours to yield results. In addition, lab equipment costs $12,000 to $20,000 per instrument compared to an estimated $1,000 to $5,000 for a biosensor.

But before the biosensor gains market acceptance, it must prove its effectiveness in the field test. The first phase will last three to six months, and researchers will compare their biosensor test results with the company's lab findings.

"One of the things we will be looking at is reproducability of results," Hartman says. "We will split a sample for testing with both of the technologies (the biosensor and lab tests). For every 1,000 tests we do, we will look for the variation between results of the two methods."

The biosensor can simultaneously detect 12 different pathogens, but researchers are concentrating on six bacterial species for now. They are Salmonella, E. coli 0157:H7, generic E. coli, Listeria monocytogenes, Campylobacter jejuni and Yersenia enterocolitica (found primarily in red meat). All of these pathogens are associated with stomach illness in humans. When detected, they are usually found in meat, but sometimes they occur in produce.

The biosensor operates with three primary components — integrated optics, immunoassay techniques and surface chemistry tests. It indirectly detects pathogens by combining immunoassays with a chemical-sensing scheme. In the immunoassay, a series of antibodies selectively recognize target bacteria. The "capture" antibody is bound to the biosensor and captures the target bacteria as it passes nearby. A set of "reporter" antibodies, which bind with the same target pathogen, contains the enzyme urease, which breaks down urea that is then added and subsequently produces ammonia. The chemical sensor detects the ammonia, affecting the optical properties of the sensor and signaling changes in transmitted laser light. These changes reveal both the presence and

concentration of specific pathogens in a sample at extremely minute levels.

"If pathogens are found with the biosensor, then food processors can make decisions more quickly about applying treatments, such as antiseptics," Edmonds says. "Or they might divert those products to cooking operations, which would kill the pathogens. And companies could modify their sanitation plans."

The integrated optic interferometric sensor technology upon which the biosensor is based has already been patented by Hartman and the Georgia Tech Research Corporation. But commercialization for the biosensor is still some time away, researchers say. After the field test at Gold Kist is completed, researchers plan to return to their laboratories to further refine the technology.

— ***Jane M. Sanders***

> **The full-text news release** version of this article is available at www.gtri.gatech.edu/res-news/SENSOR.html. **For more information,** contact Nile Hartman, GTRI, Atlanta, GA, 30332-0825. (Telephone: 404-894-3503) (E-mail: nile.hartman@gtri.gatech.edu)

The Cost of Cleaning the Air

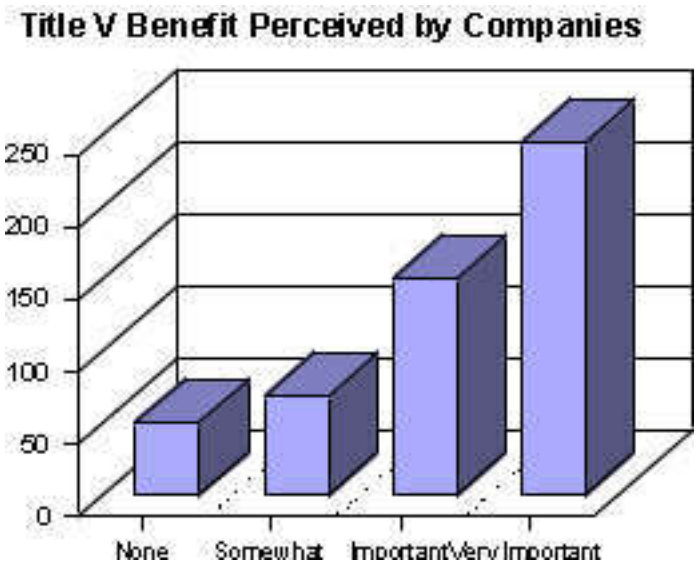
Study shows permit application costs lower than expected — with key benefits to industry.

A study of some 500 U.S. manufacturers found that the cost of applying for air emissions permits under new national regulations was lower than industry estimates. The Georgia Institute of Technology research is believed to be the first detailed examination of business costs involved in applying for permits under Title V of the 1990 Clean Air Act Amendments.

The study also produced one surprising result: three-fourths of the responding companies saw important business benefits in the new regulations.

Title V requires companies that emit certain amounts of air pollutants to document their emission sources, air pollution control equipment and

regulatory requirements in a single document. By providing a centralized source of information, the legislative goals were to help regulators enforce air quality standards, to help companies understand and comply with them, and to help citizens monitor industry compliance.



Some 77 percent of companies saw advantages in the operational flexibility provided by Title V. The bars show the number of responding companies providing each response.

"Before Title V was implemented, industry officials were concerned that the law would be costly, with no benefit to them," says Dr. Barry Bozeman, lead author of the study and a researcher in Georgia Tech's State Data and Research Center. "But the study results show that this is not the case. More often than not, the cost was modest, and complying companies found positive aspects to the law."

Corporate environmental managers responding to the survey reported their firms spent an average of $113 per employee to apply for the air emissions permits. For an average 566-person company, that translates to $63,958 per facility. Applying these costs to the estimated 20,000 facilities covered by Title V suggests the total bill for national compliance will be about $1.3 billion.

These numbers are lower than the estimates reported last spring by an industry group, says Leisha DeHart-Davis, a co-author of the study and a research associate in Georgia Tech's Air Quality Laboratory. An April 1999 report released by Washington law firm Morgan, Lewis & Bockius, LLP, estimated that the average company would spend $100,000 per facility, with a total bill of $2 billion for the 20,000 locations.

The Georgia Tech study, sponsored by the U.S. Environmental Protection Agency (EPA), provides a direct measure of permit application costs for manufacturers. DeHart-Davis cautioned that the costs reported are a "moving target" because the permitting work continues in some cases — though some 97 percent of respondents had filed applications at the time the survey was conducted.

The most significant direct costs were for outside consultants, but also included time of company personnel and expenses for new administrative systems.

The researchers used a mail survey to contact environmental managers at 1,614 randomly

selected companies in Wisconsin, Oregon, Georgia and South Carolina. These states were chosen to provide a cross-section of industry types and sizes. State response rates for the confidential surveys ranged from 31 percent to 43 percent, and yielded 542 completed questionnaires.

The researchers also contacted state environmental regulatory agencies to gain their assessment of the regulations. They obtained 90 agency responses.

— John Toon

> **The full-text news release** version of this article is available at www.gtri.gatech.edu/res-news/TITLEV.html. **For more information,** contact Leisha DeHart-Davis, Air Quality Laboratory, Georgia Tech, Atlanta, GA 30332-0340. (Telephone: 404-894-9345) (E-mail: leisha.davis@aql.eas.gatech.edu)

Measuring the Smallest Air Pollutants

Scientists conduct intensive study of fine particulate matter.

Atmospheric scientists led by Georgia Institute of Technology researchers are determining the best ways to measure the fine particulate matter that is polluting the nation's air, particularly in large urban areas.

Particulate matter, which is federally regulated, has raised concern recently because of numerous studies linking it to serious health problems. Fine particulate matter (called PM 2.5 because it is less than 2.5 microns in diameter or 30 times smaller than the diameter of a human hair) includes soot, dust, aerosols, metals and sulfates primarily emitted by vehicles and industrial sources. It contributes to the smog so common in American cities.

photo by Stanley Leary

In the first of two "SuperSite" studies initiated by the U.S. Environmental Protection Agency (EPA), about 60 scientists from the Georgia Institute of Technology and other institutions converged last summer at an Atlanta air quality research facility owned by Georgia Power. They measured PM 2.5 around the clock for one whole month. They are now analyzing that data and preparing a preliminary report for delivery to

EPA this summer.

Researchers monitored air quality equipment at their EPA SuperSite near Georgia Tech to gather data on fine particulate matter, a major contributor to the smog that plagues many urban areas.

"We are trying to determine how to measure the concentration and composition of fine particulate matter in the atmosphere and the types of instruments best suited to do that," says Dr. William Chameides, a professor in the Georgia Tech School of Earth and Atmospheric Sciences and head of the SuperSite study. "We need to do this to understand the health effects and the sources, and to monitor compliance with EPA standards."

Specifically, the research team expects to:

- evaluate emerging and/or state-of-the-science PM measurements.
- compare and contrast similar and dissimilar PM measurements.
- evaluate the precision, accuracy and completeness of information that can be gained from the planned EPA network of SuperSites.
- evaluate the scientific information gained by combining various independent and complementary PM measurements.
- address various scientific issues and their ozone- and PM-related policy implications with the database they are developing.

Chameides hopes to discover whether the production of ground-level ozone and PM 2.5 are chemically related. Both are secondary pollutants, meaning they are not directly emitted into the atmosphere, but are instead generated in the atmosphere by chemical reactions.

"It's possible that controlling one pollutant without controlling the other might make one worse," Chameides says. "The trick is to fully understand how they interact so you can come up with a strategy to deal with both of them."

Chameides is spearheading the SuperSite study under the auspices of the ongoing Southern Oxidants Study (SOS), which involves about 20 universities and agencies. EPA is providing the primary funding for the Atlanta SuperSite study. Other funds are coming from the U.S. Department of Energy, Tennessee Valley Authority, and the National Oceanic and Atmospheric Administration. Georgia Power and its parent, Southern Company, are providing the research facility and some equipment.

— Jane M. Sanders

The full-text news release version of this article is available at www.gtri.gatech.edu/res-news/SUPER.html. **For more information,** contact Dr. William Chameides, School of Earth and Atmospheric Sciences, Georgia Tech, Atlanta, GA 30332-0340. (Telephone: 404-894-1749) (E-mail: william.chameides@eas.gatech.edu). Also, you may visit the Atlanta SuperSite Study Web site at: www-wlc.eas.gatech.edu/supersite.

Charging Through DNA Like a "Slinky"

Researchers suggest new mechanism to explain DNA charge transfer process.

The compression and expansion of a "Slinky" — a child's toy made from a large spring — is how a Georgia Institute of Technology scientist describes his research team's new theory of the charge transport mechanism in DNA.

The new charge transport model, dubbed "phonon-assisted polaron-like hopping," could help scientists better understand the mechanisms by which DNA — the building blocks of life — is damaged and repaired. It could also lead to development of new diagnostic techniques based on recognition of charge transfer characteristics, and could one day open up applications for one-dimensional DNA "wires" able to assemble themselves into tiny circuits for micromachines.

photo by Gary Meek

Researcher Valerie Sartor examines DNA sequences in the laboratory of Dr. Gary Schuster, dean of the College of Sciences.

The Georgia Tech research team proposed in a report published inn the Proceedings of the National Academy of Sciences that electrical charge moves through DNA bases by creating temporary distortions in base structure as the strands naturally flex. The work suggests that the charge transport process is much more complicated than previously believed.

"It's not at all like a conductor or a wire," says Dr. Gary B. Schuster, lead author of the paper and dean of Georgia Tech's College of Sciences. "We think this answers the question of how charge transfers through DNA, at least in a broad-brush way."

Schuster explains the Slinky comparison: "When you inject a charge into DNA, the DNA responds by changing its structure to accommodate that charge. That change in structure distributes the charge over several of the base pairs in the DNA. That creates a local distortion in the DNA. That local distortion, just like the compression in the Slinky toy, can move in the DNA as the structure moves normally in stretching, bending and rotating."

The distortion, known as a polaron, can carry the charge a distance of up to a few hundred Angstroms. The charge transfer stops when it encounters a specific pairing of the DNA structure known as a GG step — the location where two guanine bases exist side by side. The charge trapped at this location then oxidizes the guanine, causing damage that can lead to genetic mutations.

An experiment conducted in Schuster's lab by Dr. Paul T. Henderson — now a post-doctoral student at the Massachusetts Institute of Technology — showed the charge moves rapidly through a duplex strand of DNA with an efficiency that is independent of the base sequence.

Using a tether just four atoms long, Henderson first created a linkage between an anthraquinone and a specific location on a 60-base DNA segment. He then irradiated the anthraquinone with ultraviolet light, causing it to inject a radical cation (a positively charged ion) into the duplex chain of DNA base pairs. He measured the progress of the cation through the DNA by observing where it damaged the strand at GG steps.

The structural independence and efficiency of the transport process were unexpected and could not be explained by existing theories of electron transport. Schuster believes two "averaging" mechanisms inherent in the polaron process tend to even out the speed of the charge transport. This new mechanism is possible only because of the dynamic nature of the DNA structure.

The research team included Denise Jones, Gregory Hampikian and Youngzhi Kan, all of Georgia Tech. The National Institutes of Health and the National Science Foundation sponsored the research.

— ***John Toon***

The full-text news release version of this article is available at www.gtri.gatech.edu/res-news/CHARGE.html. **For more information,** contact Dr. Gary Schuster, College of Sciences, Georgia Tech, Atlanta, GA 30332-0365. (Telephone: 404-894-0202) (E-mail: gary.schuster@cos.gatech.edu)

Where Oil and Water Mix

Researchers explore use of "near-critical" water for replacing conventional solvents.

Under normal conditions, oil and water don't mix. But "near-critical" water — very hot, but still liquid water at temperatures of 250 to 300 degrees C and pressures of 1,000 psi — can be a good solvent for both salts and non-polar organic compounds, including oils. This makes ordinary water an ideal reaction solvent for certain chemical processes.

Researchers at the Georgia Institute of Technology are studying a wide range of chemical processes in search of applications in which the special properties of this "near-critical" water might provide both economic and environmental advantages. Their work could lead to replacement of traditional organic solvents in certain specialty chemical processes.

photo by Gary Meek

Georgia Tech researcher Josh Brown examines the results of reactions run in near-critical water.

"Our goal is to do the technical work to see where we can use this as a replacement process, and to couple that with an economic analysis to see where this can be used profitably," says Dr. Charles Eckert, director of Georgia Tech's Specialty Separations Center and a professor in the School of Chemical Engineering.

Certain types of chemical reactions operate well in near-critical water and would be top candidates for the new process, he says. Use of water as a solvent could also be attractive for processes in which all traces of hazardous solvents must be removed — such as in pharmaceutical manufacturing.

In addition to Eckert, the research team included Dr. Charles Liotta, Georgia Tech's Vice-Provost for Research and a professor of chemistry; Dr. Roger Glaser, a post-doctoral fellow; and Ph.D. students James Brown and Shane Nolen.

"Water is about as ideal a solvent as you could imagine," Eckert notes. "Not only is it benign, but the public perception is that it is benign."

Both the benign nature of water and its potential as a powerful solvent depend on its unique system of hydrogen bonding. As water is heated, its normally strong hydrogen bonds weaken, allowing dissociation that forms acidic hydronium ions and basic

hydroxide ions. At the near-critical stage, the amount of dissociation is three times what it would be at normal temperatures and pressures.

"Simply from the dissociation of water into acidic and basic ions, a much larger amount of acid and base is present in near-critical water," Eckert explains. "We can use these to run acid-catalyzed and base-catalyzed reactions without the addition of mineral acid."

Near-critical water has properties similar to those of polar organic solvents like ethyl alcohol or acetone. Its dielectric constant drops from 80 to 20, and its density drops from one gram per cubic centimeter to 7/10 gram per cubic centimeter.

"What all this means is that molecules that would normally not be soluble in the same solvent become soluble together in near-critical water and can be processed together," he says. "Virtually all organics are soluble or completely miscible in water above about 250 degrees C."

Dissolving organics in near-critical water allows some reactions now done in multiple phases to be completed in a single aqueous phase. This eliminates high cost and energy associated with stirring rapidly and separating unwanted additives from the final product.

— ***John Toon***

> **The full-text news release** version of this article is available at www.gtri.gatech.edu/res-news/CRITICAL.html. **For more information,** contact Dr. Charles Eckert, School of Chemical Engineering, Georgia Tech, Atlanta, GA 30332-0100. (Telephone: 404-894-7070) (E-mail: charles.eckert@che.gatech.edu).

MRI for Carpets & Fabrics

Researchers apply medical diagnostic tool to a wide range of industrial challenges.

Magnetic resonance imaging (MRI) has significantly enhanced diagnostic medicine by allowing physicians to look deep inside the human body without using a scalpel.

Now, researchers at the Georgia Institute of Technology are applying the technique to a broad range of industrial processes, using MRI to watch carpet dry from the inside, peer into peanut shells, and study how fabrics wick moisture away from the

body. The work could lead to faster and more efficient drying processes, carpet less prone to mildew and fabrics that are more comfortable to wear.

photo by Stanley Leary

Researchers Haskell Beckham, left, and Johannes Leisen prepare carpet samples for MRI examination.

"The advantages for us are the same as for the medical community," explains Dr. Haskell W. Beckham, associate professor in Georgia Tech's School of Textile and Fiber Engineering. "The technique is non-invasive; we don't need special tracers, dyes or contrast agents for image capture; and information can be extracted from arbitrary locations inside opaque objects."

The Georgia Tech researchers are believed to be the only ones in the world using MRI to study textile drying.

Using the instrumentation in Georgia Tech's Nuclear Magnetic Resonance Center, Beckham and his collaborators have examined how moisture flows into carpets, measured where it accumulates and monitored its removal as a function of time during conditions simulating industrial drying processes. They've also seen how surface fluorocarbon finishes affect the way water penetrates the carpet.

While such information on fluid behavior within textiles is important in itself, it also provides a means for describing the internal structure of the material. This is especially useful for soft porous substrates such as textiles; the traditional method requires physically cutting the sample into thin slices and then examining each slice using microscopy. Soft materials are easily deformed during such sample preparations.

The MRI technique has the unique ability to follow fluid distribution in real time. "For carpets and textiles, you can't get this information any other way," Beckham says. "Simply stated, all we do is wet the sample, put it in the instrument and take snapshot images as a function of drying time."

Beckham's collaborators in the work are Dr. Wallace W. Carr and Dr. Johannes Leisen of Georgia Tech, and Dr. Hubert Kinser of Dalton College.

Magnetic resonance imaging uses powerful magnetic fields to align the magnetic moments of the nuclei in molecules. Following an excitation pulse of electromagnetic

radiation, the nuclei return to their original state and give off a signal that can be measured and analyzed, showing scientists where the molecules are located.

The Georgia Tech MRI instrument is much smaller than a hospital machine designed for imaging the human body. Beckham and his collaborators study a sample about one inch in diameter, imaging it repeatedly to see how moisture levels change over time as they apply heated air.

— ***John Toon***

> The full-text news release version of this article is available at www.gtri.gatech.edu/res-news/MRI.html. For more information, contact Dr. Haskell Beckham, School of Textile and Fiber Engineering, Georgia Tech, Atlanta, GA 30332-0295. (Telephone: 404-894-4198) (E-mail: haskell.beckham@textiles.gatech.edu)

Also see *Research Links* news stories.

Research Horizons

Research Links...

Measuring Environmental Performance

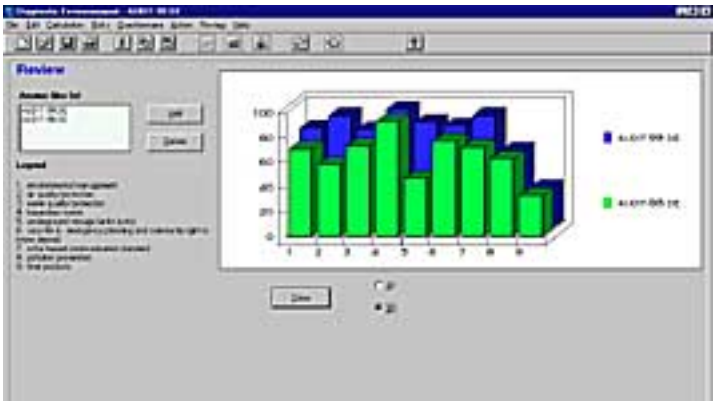
Software developed at Georgia Tech is assessing regulatory compliance.

Environmental management software developed at Georgia Tech has been deployed statewide and nationally.

Called EcoDiagnosis, the self-assessment tool was previously test marketed nationwide, and 75 percent of companies involved rated it "good" or "excellent." Seventeen Georgia firms participated in testing the tool.

As currently available, EcoDiagnosis covers more regulatory categories — such as stormwater permitting and spill prevention, control and countermeasures — in addition to the original 10 topic areas.

courtesy Roc Tschirhart



An environmental management software program developed at Georgia Tech contains a benchmarking component to track a company's level of performance. (Click on the image to see larger 124k version).

Development of the software was sponsored by the National Institute of Standards and Technology (NIST), which wanted a useful and affordable environmental performance measure for the country's numerous small manufacturers. EcoDiagnosis, says Georgia Tech project manager Roc Tschirhart, is now widely available through NIST's Manufacturing Extension Partnership centers. Cost is in the $250 range.

Adapted to the American business and regulatory environment from a successful French model, EcoDiagnosis allows manufacturers to see what regulations apply to their facilities and gives them a European perspective on labeling, product lifecycle and ongoing environmental management, Tschirhart notes. It also contains a benchmarking component to track levels of performance (see accompanying chart) and it provides guidance on remedying deficiencies.

— Lincoln Bates

For more information, contact Roc Tschirhart, Electro-Optics, Environment and Materials Laboratory, Georgia Tech Research Institute, Atlanta, GA 30332-0837. (Telephone: 404-894-8045) (E-mail: roc.tschirhart@gtri.gatech.edu) For more information on EcoDiagnosis, see a previous Research Horizons article at http://www.gtri.gatech.edu/rh-spr98/rnotS98.html#rnote4.

Smarter Web Browsing

Researcher develops tools for building artificial intelligence in software.

Using the latest techniques in artificial intelligence — which include human memory algorithms and machine learning — a team of Georgia Institute of Technology researchers has created EnkiaGuide, a personal recommendation engine for Internet portals.

EnkiaGuide enhances a surfer's Web experience by suggesting Web sites based on the user's preferences and current browsing patterns. For example, the system can suggest Web content based on a specific geographic location.

The developer, College of Computing Associate Professor Dr. Ashwin Ram, and several colleagues founded Enkia Corporation in November 1998 to commercialize the technology. The company is a member of the Advanced Technology Development Center, Georgia Tech's incubator for advanced technology companies.

The new product also has benefits for operators of Web portals.

"A big selling point for portals is stickiness," explains Dr. Ram, Enkia's CEO. "Portals can use the EnkiaGuide to extend the time the user spends associated with the portal's site."

To stay competitive in the portal business, companies need to add features that create new ways to retain users and attract advertising revenue, he says. Currently, the problem for Web portals is that many users search for keywords and immediately leave the portal to look at the Web addresses that the portal finds.

"EnkiaGuide helps anyone find their 'needles' in haystacks of data on and off the Internet," Dr. Ram adds. "It can help users find their way through technical support libraries or large e-commerce sites, and allow corporations to organize pathways through their large proprietary databases. The EnkiaGuide can make sense out of information chaos."

The EnkiaGuide will help make the next generation of information browsers smarter and more effective, reducing the complexity of web information and helping Web surfers find relevant answers to their questions.

Co-founders Anthony Francis, Enkia's vice president of research & development, and Mark Devaney, vice president of product development, developed the AI technology now used at Enkia while earning their doctoral degrees in intelligent systems at Georgia Tech. Bob Kinnett, vice president of marketing and business development, brings 15 years of entrepreneurial management and marketing experience to Enkia.

— Amanda Allen

> **For more information,** contact Dr. Ashwin Ram, Enkia Corporation, 430 Tenth Street NW, ATDC Suite N107, Atlanta, Georgia 30318. (Telephone: 404-874-8882) (Email:ashwin@enkia.com)

Mammograms at Internet Speed

Advanced Internet technology makes mammography more efficient; adds computerized "second opinion."

What's next on the Internet? How about using it as an electronic intermediary for mammography image data and diagnostic reports, speeding the flow of information between mammography clinics, radiologists, referring physicians and patients?

The idea originated with a Georgia Institute of Technology professor who last fall launched Medizeus, a company that aims to improve the speed and efficiency of mammography testing. Medizeus is a new member company in Georgia Tech's Advanced Technology Development Center (ATDC).

Using advanced Internet technology, the company transforms a multi-step paper-based process into a more efficient and faster electronic one. Medizeus could reduce the time required for mammography results from a week to as little as a few hours.

While speeding up the flow of information, Medizeus also boosts accuracy by offering

medical personnel a computerized "second opinion" from an advanced artificial intelligence system.

"There are multiple advantages for each person in the healthcare sector," says mechanical engineering professor Dr. David Ku, president and CEO of the company. "For the doctors — both referring physicians and radiologists — we increase the accuracy so they are practicing better medicine, and we increase their efficiency, so they can get more reports out in less time. By using an electronic system, there are also savings in recordkeeping and report writing."

Patients will also be able to access their medical records from anywhere in the world. Archiving this data will make baseline reports readily available even when patients change physicians. Its archived mammogram data will also allow Medizeus to support research studies on test frequency and benefits.

The Medizeus system is now in beta testing. Mammogram images produced in clinics scattered around the area are sent to Medizeus electronically. The company forwards them to participating radiologists, who analyze the images and attach their diagnostic reports to the image file. Physicians then use a Web-based interface to view the images and reports. The information can be sent electronically to billers, and also becomes available to patients using the same Web-based interface.

— John Toon

> **The full-text news release** version of this article is available at www.atdc.org/companies/november191999.html. **For more information,** you may contact Dr. David Ku, School of Mechanical Engineering, Georgia Tech, Atlanta, GA 30332-0405. (Telephone: 404-894-6827) (E-mail: david.ku@me.gatech.edu)

Endowing Research

Tech's analog engineering program receives $1.5 million gift from ON Semiconductor.

ON Semiconductor, formerly a division of Motorola, is providing $1.5 million to Georgia Tech's School of Electrical and Computer Engineering (ECE) to endow the ON Semiconductor Professorship in Analog Integrated Circuit Design and the ON Semiconductor Graduate Fellows Program.

To strengthen the analog programs, the endowment will be used to support two junior faculty members for three years each, and then the endowment will support a senior

endowed chair.

The gift will help support the Yamacraw Mission, a year-old effort to develop high-bandwidth communications businesses by the University System of Georgia; the Georgia Department of Industry, Trade and Tourism; and the Georgia Research Alliance. The first of the two ON Semiconductor junior faculty to be hired, J. Stevenson Kenney, will be involved in the Yamacraw Mission.

"The research agenda of Yamacraw extends from basic 'system-on-a-chip' electronics through design of wireless and broadband communications systems," says ECE chair Dr. Roger P. Webb. "Steve Kenney's expertise and experience in electronic design for wireless systems places him exactly at the intersection of the interests of ON Semiconductor and the Yamacraw Mission."

With this donation, ON Semiconductor, a supplier of analog, logic and discrete semiconductor components, continues its longstanding association with ECE. The first ON Semiconductor program will support two assistant professors with proven skills in analog IC design and who exhibit exceptional promise for future program growth and development. Recruiting is complete for one position, and the second will be staffed in 2001, says J. Alvin Connelly, professor and associate chair in ECE. Funding for each position will last three years.

Funds from this gift will establish the ON Semiconductor Graduate Fellows Program. These monies will assist the two new junior faculty members with immediate support of graduate students and will enable them to jump start their research programs in directions of critical interest and importance to ON Semiconductor. Each faculty member will be able to support three M.S. students and one Ph.D. student.

— Jackie Nemeth

> **For more information,** contact Dr. Roger Webb, School of Electrical and Computer Engineering, Georgia Tech, Atlanta, GA 30332-0250. (Telephone: 404-894-2902) (E-mail: roger.webb@ee.gatech.edu)

Awards and Honors

Georgia Tech faculty receive recognition.

Dr. Krishan Ahuja was recently named American Institute of Aeronautics and Astronautics Region II Engineer of the Year and is being considered for national honors. Ahuja is a Regents' researcher and professor of aerospace engineering. He conducts research in the Georgia Tech Research Institute's Aerospace, Transportation and

Advanced Systems Laboratory.

Dr. Mark Guzdial, an associate professor in the College of Computing, led a research team that received one of two national awards in the AIA Honors Awards Competition for their research project "CoOL Studio: Expanding the Discursive Space of the Design Studio with Educational Technology." The project is an Internet-based studio environment that allows participants in disparate geographical areas to discuss and critique projects. His colleagues were College of Architecture Assistant Professor Dr. Sabir Khan and Associate Professor Dr. Craig Zimring.

Dr. Christopher Hertzog, a professor in the School of Psychology, received a Method to Extend Research in Time (MERIT) Award from the National Institute on Aging. MERIT awards are given to exceptional senior scientists with outstanding proposals. Hertzog's research combines differential psychology and experimental cognitive psychology to better understand age changes in cognitive processes.

The School of Chemistry and Biochemistry's new Assistant Professor **Dr. C. David Sherrill** received one of 13 Camille and Henry Dreyfus New Faculty Awards. The program is designed to provide external research support to new faculty members at the start of their research and teaching careers. Sherrill's research focuses on the applications of the principles of quantum mechanics and electronic structure theory to address problems in physical, organic, inorganic and biological chemistry.

Dr. Charles Ume, a professor in the School of Mechanical Engineering, received the 1999 E.G. Bailey Award from the Instrument Society of America in recognition of the design and development of a novel automated online flatness measurement and analysis instrument.

Also see *Research Notes* news stories.

Contents Research Horizons GT Research News GTRI Georgia Tech

Send questions and comments regarding these pages to Webmaster@gtri.gatech.edu

Last updated: February 10, 2000

ResearchHorizons

Would You Like to Be My Neighbor?

State-of-the-art research "neighborhood" complexes will promote collaboration and foster economic development.

By Jane M. Sanders

Buildings, though inanimate, can actually foster interdisciplinary and private industry collaboration on a research university campus. And that is the goal at the Georgia Institute of Technology in building three new state-of-the-art research complexes.

"Many universities pay lip service to interdisciplinary endeavors," President Wayne Clough recently told the faculty and staff, "but Georgia Tech is actually becoming interdisciplinary from the ground up."

photo by Stanley Leary

The $31.7 million Institute for Bioengineering and Bioscience building opened 150,000 square feet of research space last summer. It is part of Georgia Tech's new Biotechnology-Environmental Science & Technology-Molecular & Materials Science (BEM) Complex.

Three interdisciplinary research "neighborhood" complexes are under development or planned. Two complexes have new facilities already open or expected to open this spring. The flexible design of a research "neighborhood" encourages interaction, collaboration and the exchange of ideas among faculty and students from multiple disciplines. Its workspaces can be cross-assigned to accommodate changes in research direction.

An important part of the interdisciplinary effort is Georgia Tech's Biotechnology-Environmental Science & Technology-Molecular & Materials Science (BEM) Complex. It is a neighborhood of four state-of-the-art buildings that will house researchers from the schools of Biomedical Engineering, Chemical Engineering, Mechanical Engineering, Electrical and Computer Engineering, Civil and Environmental Engineering, Biology, Chemistry and Biochemistry, Earth and Atmospheric Sciences, and the College of Computing.

The first facility in the BEM Complex, the $31.7 million Institute for Bioengineering and Bioscience building (IBB), opened with 150,000 gross square feet of research space last summer. (See campus map.) A second facility, the $58 million Environmental Science and Technology (EST) Building, will break ground this winter. Its 261,000 gross square feet will be used for a combination of research and educational uses.

Fundraising is under way for a third facility, the 70,000-gross-square-foot Biomedical Engineering building, which will be physically connected to IBB and will house the School of Biomedical Engineering and the joint Georgia Tech/Emory University biomedical academic and research program. A fourth research building, the 200,000- to 250,000-gross-square-foot Molecular and Materials Science and Engineering facility, is in the planning stages, with construction expected to begin in 2002.

These buildings are the most modern and most expensive buildings ever to be constructed at Georgia Tech. "The last building built for sciences on campus was finished about 30 years ago when Tech wasn't a major research institution," says Dr. Michael Thomas, provost and vice president of academic affairs. "Thus these buildings were not designed to support such efforts. In addition, the types of buildings needed to support scientific research have changed substantially in the last 30 years, even in the past five to 10 years. We are operating at a severe disadvantage with the current buildings in trying to recruit research-active faculty. These buildings will address that issue."

The second complex is devoted to manufacturing research. Two of the buildings in this neighborhood, the Manufacturing Research Center and the Manufacturing Related Disciplines Center I, have been in use for several years. The new element, the $27.3 million Manufacturing Related Disciplines Center II, is expected to open in April. The 151,000-gross-square-foot academic and research building will house the schools of Mechanical Engineering and Materials Science & Engineering. The building will also include several classrooms.

Georgia Tech's administration is also making plans for a third research neighborhood with the addition of a new building to facilitate interdisciplinary research between the College of Computing and the School of Electrical and Computer Engineering. The new building will be constructed near the existing college and school facilities, reinforcing the notion of

an "information technology complex." It will include research laboratories, classrooms and instructional facilities.

The three new research neighborhoods will not only benefit Georgia Tech's teaching and research programs, they will also contribute to economic development in the state and enhance student experiences, Thomas says. The EST building, for example, will provide incubator space for new high-tech businesses supported by the Advanced Technology Development Center. Some of the start-up companies there will certainly be the products of research done in the building, Thomas adds. As for students, they will be better prepared for the workplace by having access to modern research labs on their campus.

These facilities will help to strategically address the tremendous growth that Georgia Tech has experienced in the past several years, Clough explains. And they will provide the elbowroom needed for the overdue task of renovating the historic core of campus.

"We'd like to renovate all of these older buildings and put them to use in a new way," Clough says. "Our goal is to adapt them to offices and uses that fit their historic character."

In addition, an Executive and Continuing Education Center is planned to meet the growing demands of technical professionals who want to stay current in their fields, Clough says.

With all of this activity ongoing, Clough and his administration have great expectations for Georgia Tech's future research capabilities, educational opportunities and economic development influence.

For more information, you may contact Dr. Michael Thomas, Provost and Vice President of Academic Affairs, Carnegie Building, Georgia Institute of Technology, Atlanta, GA 30332-0325. (Telephone: 404-894-5056) (E-mail: michael.thomas@carnegie.gatech.edu)