ENGINEERING AT ILLINOIS

CONNECT

NEWSLETTER OF THE COORDINATED SCIENCE LABORATORY VOL. FOUR, NO. 1 | 2012

CSL researchers head $1 million surveillance network research

If the surveillance network research underway at Illinois had existed in the 1940s, Pearl Harbor may have been better prepared to counter an invasion.

CSL Professor Petros Voulgaris (Aerospace Engineering) is leading a multi-university group in an approximately $1 million grant over three years from the Air Force Office of Scientific Research (AFOSR) to determine how sophisticated, unmanned surveillance vehicles can provide navy antiterrorism and force protection measures in harbors.

The researchers envision a heterogeneous group of ground, underwater, surface, and aerial unmanned vehicles monitoring the Navy fleet and ports. They believe that aerial autonomous surveillance of vessel traffic, current and wave patterns, and ocean weather conditions can enhance the military's ability to coordinate autonomous surveillance agents positioned underwater and on the surface.

The proposal presents a complex problem of using a large network of decentralized autonomous agents with various sensing capabilities to work together to provide a massive amount of data. The scientists must also take into consideration uncertainties, including potential sensor and communication link errors.

"We consider multi-autonomous systems tasks with minimal information so that the complexity is reduced and we can deal with the massive amounts of data. The present amount of data is too much to accomplish the coordination task," Voulgaris said.

Voulgaris' research interests include robust and optimal control and estimation, structured and distributed control, networks and control, and applications of advanced control and estimation methods to engineering practice.

Voulgaris will be working on the project with fellow CSL researchers Soon-Jo Chung (Aerospace Engineering),

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From the Director

In a posthumous tribute to former CSL Professor Mac Van Valkenburg, his student Steven B. Sample called his mentor "a teacher of teachers."

Van Valkenburg famously delivered entertaining lectures on circuit analysis and synthesis with colored-chalk illustrations that his students still fondly recall. His textbook, "Network Analysis," remained a decades-long standard for teaching modern circuit and system theory, thanks to his clear and concise handling of complex topics. And perhaps most importantly, the "Guru" of electrical engineering education helped shape the next-generation of educators through his tireless mentorship of students and young faculty members throughout his career.

The College of Engineering will honor these accomplishments and many others by posthumously inducting Van Valkenburg into the Engineering at Illinois Hall of Fame on September 14. (Sample, a former CSL student who served as president at the University of Southern California from 1991 to 2010, will share the honor with his mentor.)

The induction of a beloved former professor and student serves as a reminder that even though CSL might be heralded primarily for its research, education has always been our foundation. CSL serves as a living classroom where instruction takes place in every office, laboratory and hallway. Undergraduate and graduate students are free to explore new ideas or approach established ideas in new ways.

The Laboratory has long attracted faculty who are strongly committed to traditional classroom education, along with the kind of learning that can only occur in a place deeply committed to solving some of the world's biggest problems.

Just this spring, for example, several CSL faculty members and research affiliates received funding from the College of Engineering's Strategic Instructional Initiatives Program (SIIP) to "reengineer" the College's course offerings.

The initiatives include:

- **Creating the World's Best Computer Engineering Core," with CSL Professors Douglas L. Jones and Steven Lumetta (both Electrical and Computer Engineering)**
- **First Year Plane for Teaching Computing at Scale," with Lawrence Angrave, Margaret Fleck, Cinda Heeren, Leonard Pitt and PCI Researcher Craig Zilles (all Computer Science)**

In his message on the topic, Dean Ilesanmi Adeisda said his goal for the program is "to improve the efficiency of delivering important gateway classes and to better relate learning to engineering practice."

It's no coincidence, I believe, that CSL researchers and institute affiliates are involved in two of the five SIIP projects. We have been making the leap between learning and the real world for more than six decades.

Former IEEE President Joseph Bordogna said of Van Valkenburg: "One of Mac's greatest gifts was to be able to tap into and set fire to that innate desire of every individual to learn and to know."

I hope that our alumni remember CSL as a place that fostered a similar passion for learning in their lives. We are grateful to Van Valkenburg for being such an outstanding role model and will work to uphold his timeless legacy.

Sincerely,
William H. Sanders

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TECHNOLOGY IN SPORTS: THE NEW GAME-CHANGER

When most people watched the London Olympic Games this summer, they focused on the unfolding competitions, or on their country's team. Information Trust Institute researcher Rayvon Fouché focused on something else: the role technology is playing on the field, and the extent to which technology is determining the outcome of the game—even reshaping the very nature of athletics.

Fouché, who is an associate professor in the Department of History at Illinois, has been studying the impact of technology on sports culture. He has considered everything from the practical problems faced by governing bodies that must rule on which equipment is permissible, to the deeper questions raised by technologies that influence outcomes to the point that they threaten sports' inherent appeal. If sports are compelling because they reveal the supposed truth about competitors' relative athletic merits, what does it mean when winners and losers are determined in part by who has access to the best techno-scientific support?

"Seventy-five years ago, a small group of dedicated craftsmen or even the competitors themselves designed and constructed athletic equipment," Fouché observes. "In the early 20th century, athletics was seen as a leisurely activity, and having a coach often was seen as problematic; even training itself was seen as ungentlemanly. You were supposed to win, but not try too hard to win." Times have certainly changed, especially over the last thirty years, which have seen the transformation of sports into a high-stakes, large-scale corporate enterprise. "It's impossible to compete in contemporary sport without the support of modern advances in science and technology."

Technologies now exist that are powerful enough to dramatically influence the outcomes of sporting events. For example, where does the sports world draw the line between performance-enhancing substances and legitimate medications that athletes might need in order to treat medical conditions? What does it mean for a competition if a crucial technology is available only to a subset of the competitors?

The problem is far from hypothetical. Fouché notes the example of the polyurethane Speedo LZR swimsuits, which marked the culmination of over 10 years of research on "fastskin" suits. "Eventually they hit on a technology that made a precipitous leap at a crucial historical moment," he observes—and that specific moment happened to be just weeks before the 2008 Summer Olympics in Beijing. Three world records were broken in the new suit within a week of its launch, and the Olympic results spoke volumes: swimmers wearing LZR suits won over 98% of the medals at Beijing.

The problem? Most of the Olympic competitors didn't have the suits, which were given only to swimmers sponsored by Speedo. "Some countries had contractual obligations, so their suits had to come from other manufacturers," Fouché explains. "Some athletes were actually borrowing swimsuits from other competitors to compete." Fans and athletes were both left with the troubling sense that the competition had been unfairly stacked in favor of those who were lucky enough to have the LZRs.

Fouché says that there's really just one area in which fans feel comfortable with the rising influence of technology on sport: instant replay. "They love technologies that will 'set the game right.' When a bad call is made, where it can override a human failing and set it right—the fans love that."

People are far more uneasy with thinking about how high-tech equipment, or even modification of the human body, is affecting performance. "I think that elite-level sport is about fans living vicariously through the sporting heroes," says Fouché. "We like our sporting heroes pure and unadulterated. And the moment you think that there might be some other technology assisting them in their performance, it undermines everything you've been trained to believe and desire."

He says that governing bodies are responsible for maintaining the collective trust and belief in sport. They have a vested interest in ensuring that their sports do not migrate from being competitions among athletes to being competitions among engineers. "You don't want to cheer for the pharmaceutical company, and have the body just be a mediator of this other competition. You want to cheer for the individual," he says.

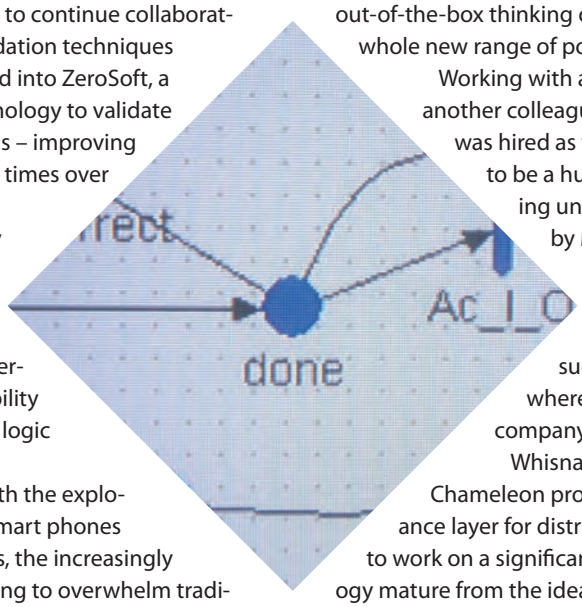
Fouché is writing a book that will explore the impact of technology on sporting cultures, projected for publication in the summer of 2013.

Alums create new verification software with start-up ZeroSoft

By Kim Gudeman

As graduate students in CSL Prof. Ravi Iyer's DEPEND group, Claudio Basile and Keith Whisnant worked together to solve fundamental problems in software fault tolerance and reliability.

So after they graduated, both with Ph.Ds in electrical and computer engineering, it made sense to continue collaborating, this time in developing logic validation techniques for hardware. The collaboration turned into ZeroSoft, a start-up that designed software technology to validate complex integrated circuit (IC) designs – improving logic simulation throughput by many times over leading solutions.



"The industry needed a new way of thinking about the verification problem," said co-founder Basile, who graduated from Illinois in 2005. "ZeroSoft took key concepts for accelerating fault simulations from the reliability space, and applied those concepts to logic simulation."

The timing proved fortuitous: with the explosion of new computer devices from smart phones to high-performance supercomputers, the increasingly complex digital designs were beginning to overwhelm traditional logic simulators on the market. Verification demands were outpacing the performance of traditional simulators, which were optimized to run one test at a time.

In order to push through more verification tests in the same amount of time, customers had to grow their data centers. They had to buy more computing power, hire additional IT people to manage the equipment and spend more money on software licenses and energy costs. Without those investments, companies lost time, money and, in some cases, the opportunity to be the first to market with a product.

"We thought, 'Why can't we build a new simulator that would be able to perform multiple tests at a time from the ground up?'" said Whisnant, a 2003 Illinois graduate who served as ZeroSoft's principal engineer. "Our backgrounds really helped us do some out-of-the-box thinking on this, and we were able to explore a whole new range of possibilities that hadn't existed before."

Working with a contact in the Bay area, Basile and another colleague launched ZeroSoft in 2007. Whisnant was hired as the first engineer. The start-up proved to be a huge success, with the company receiving unsolicited buy-out offers. It was acquired by Mountain View, Calif-based Synopsys in 2010 for an undisclosed amount.

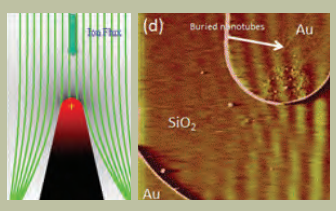
The Illinois alums say their time at CSL helped prepare them for their success at ZeroSoft and then at Synopsys, where they worked for two years following the company's acquisition.

Whisnant said his graduate work on the Chameleon project, a software-implemented fault tolerance layer for distributed systems, was a great opportunity to work on a significant software project and see the technology mature from the idea stage to becoming a real product.

Basile, who created algorithms for distributed computing for wired and wireless networks, credited his work with Iyer and CSL Professor Wen-mei Hwu, the Sanders III Advanced Micro Devices, Inc., Endowed Chair, in shaping his success. Both professors are members of Illinois' electrical and computer engineering faculty.

"We really had to defend our ideas, which was an extremely valuable skill when it comes to presenting to potential investors," he said. "You can have the most interesting software in the world, but if you can't sell it, it won't go anywhere. Ravi taught me a lot about how to do that."

Microscope probe-sharpening technique improves resolution, durability



A simple new improvement to an essential microscope component could greatly improve imaging for researchers who study the very small, from cells to computer chips.

CSL Professor Joseph Lyding, a professor of electrical and computer engineering, led a group that developed a new microscope probe-sharpening technique. The technique is described in research published in the journal Nature Communications.

Scanning probe microscopes provide images of tiny structures with high resolution at the atomic scale. The tip of the probe skims the surface of a sample to measure mechanical, electrical or chemical properties. Such microscopes are widely used among researchers who work with tiny structures in fields from nanotechnology to cellular biology. However, probes can degrade rapidly with use, wearing down and losing resolution.

To shape tips, researchers shoot a stream of ions at the tip. Lyding had the simple, novel idea of applying a matching voltage to the tip to deflect the incoming ions. When a voltage is applied to a sharp object, the electrical field gets stronger as the point narrows. Therefore, ions approaching the sharpest part of the electrified tip are deflected the most.

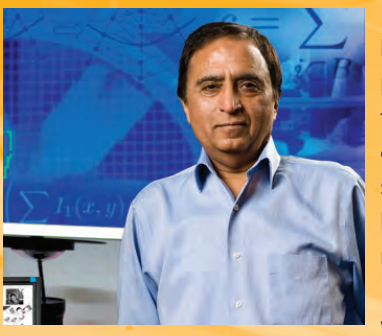
He then teamed up with CSL Professor John Abelson (MatSe) and chemistry professor Gregory Girolami to make the tips durable. The group applied hafnium diboride coatings to their probes, sputtered them further, and found that the resulting probes are stable, durable and excel in the types of microscopy and patterning applications for which such tips are used.

The researchers now are moving to commercialize their tough, sharp probes. They received a patent and started a company called Tiptek to begin manufacture. They are also expanding their sharpening technique to include AFM probes as well as STM, and are developing batch-processing techniques for higher throughput.

Ahuja to design automated systems for categorizing visual data

By Elise King

As the volume of digital information continues to grow, automated systems for categorizing visual data are becoming increasingly important in order to keep visual data organized and allow people to access the data they need in a quick, efficient and relevant way.



CSL Professor Narendra Ahuja recently received a 3-year, $419,655 grant from the Office of Naval Research to design this type of automated system. Through this grant Ahuja, a Donald Biggar Willet Professor in electrical and computer engineering, hopes to develop an image matching framework that can be used to program computers to learn and recognize whether and where objects appear in images.

Ahuja previously received an NSF EAGER grant to research the problem of categorizing visual data. Through this recent ONR grant, Ahuja and other researchers will build off of the strengths of existing approaches used in previous research to take a new approach to this problem: using regions to capture the basic information for recognizing objects.

By utilizing region-based representation, computers will be programmed to use regions as features and can therefore detect things such as the relative spatial layout of an object in order to recognize the object.

The computers that will use this framework will be able to learn objects by being shown a series of images, and then will be able to recognize those objects in new images without human supervision. This kind of technology can be used for everyday purposes such video surveillance and medical purposes. Ahuja said that, for example, a computer programmed to categorize visual data can be shown a series of images that contain brain tumors so that it learns what a brain tumor looks like. Then it can be told to look at a new patient's brain scans and will be able to locate and identify brain tumors on its own.

Similarly, Ahuja said, if it is against the rules for someone to enter a locker room alone, this computer can be taught to recognize the difference between one person and multiple people, and can then monitor video surveillance to see if only one person enters the locker room. If only one person goes in to the room then a warning alarm will sound.

Researchers want to also make sure this technology is accurate, robust and fast. "You have to be tolerant of variability, but not too tolerant," Ahuja said. The computer should be able to tell that a bright red apple and a dark red apple are still both apples, but an apple and an orange are different.

"If you don't know what matters you will be inaccurate," Ahuja said.

Nahrstedt wins IEEE Computer Society Technical Achievement Award for 2012

CSL Professor Klara Nahrstedt has been named the winner of a prestigious IEEE Computer Society Technical Achievement Award for 2012.

The Technical Achievement Award honors "outstanding and innovative contributions to the fields of computer and information science and engineering or computer technology." According to the citation for the award, Nahrstedt is being honored "for pioneering contributions to end-to-end quality of service and resource management in wired and wireless networks."

Nahrstedt has a long history of distinguished contributions to quality of service (QoS) routing. In the earliest phase of that work, running from 1997 to 2005, she addressed the problem in the context of wired networks, eventually producing a suite of leading QoS routing algorithms.

Around 2002 she turned her attention to the much greater challenge of QoS routing in wireless networks. Whereas wired networks enjoy a physically protected environment in which strong guarantees are relatively easy to provide, wireless networks are subject to highly unpredictable conditions and interference. In the third and most recent major phase of this work, she has studied ways to provide QoS guarantees in the even more challenging context of tele-immersion.

Today, she is pursuing QoS management research on multiple fronts. The tele-immersion work, which has been supported by the National Science Foundation, has been ongoing since 2004. In other work -- funded by Qualcomm, Intel, Google, and the Boeing Trusted Software Center in ITI -- she has been working to address the QoS problems of mobile telephones and mobile computing through grouping strategies. She is developing approaches that would allow phones to help each other via collaborative groupings.

Finally, through work in ITI's Trustworthy Cyber Infrastructure for the Power Grid (TCIPG) Center, she is also looking at how competing QoS and security demands can both be answered in the context of critical cyber-physical systems, such as the power grid.

Rural girls using social media to overcome obstacles

Aimee Rickman, a Ph.D. student in human and community development and a research assistant for CSL Associate Professor Christian Sandvig (Media), has a long list of honors and awards for the work she has done studying the social construction of adolescence. Now she can add two new honors to that list: a 2012-13 fellowship from the Illinois Program for Research in the Humanities (IPRH) and the Sadker Dissertation Award from the Myra Sadker Foundation.

"I'm thrilled, I'm so honored to be a part of both these groups," Rickman said. Both the fellowship and the award will help Rickman develop her dissertation, which will examine how rural girls' use of and involvement with social media effects their lives.

Rickman says that when girls are online, people often view them in one of two ways: either as people who are at risk and need protecting or as people who are out of control socially and cause problems. "But what they're doing online often doesn't fit into these two framings," Rickman said. Through her research, Rickman has found that these girls have thought a lot about how to keep their personal information safe online and are not being reckless.

"They address the obstacles they have in their life" using the internet, Rickman said. Girls in rural areas often use social media to connect to other people when there is no other practical way.

"They're doing some really meaningful things online that help them make sense of the world," Rickman said. She also said that the internet is a very important part of these girls' lives; it's not just for entertainment.

Rickman has worked with girls for a number of years in several ways, including co-founding a community youth group, working for Women in Engineering, leading girls' camps and establishing a science camp.

Her research focuses on two groups -- girls and rural youth -- that are understudied populations. Rickman studies girls between the ages of 13 and 22, although she says the boundaries of adolescence are vague.

"I'm interested in how we frame this period of adolescence," said Rickman, who noted that various cultures define adolescence differently, or don't have a period of adolescence at all.

Rickman has studied other areas including online hostilities (often known as "cyber bullying") and the effect that comment boards have on public opinion.

CSL PROFESSOR ADESIDA NAMED PROVOST AT URBANA

CSL Professor and College of Engineering Dean Ilesanmi Adesida has been named vice chancellor for academic affairs and provost of the Urbana campus. He will assume his new role on August 16.

Adesida, an electrical and computer engineering professor, has served in various roles since becoming a University of Illinois faculty member in 1987. Named dean in 2006, he also has been a director of the Center for Nanoscale Science and Technology since 2001.

Adesida will play a critical role in developing and executing the next steps in the Visioning Future Excellence initiative, which has challenged staff and faculty members to submit new ideas that will be used to plot the Urbana campus's course far into the future, according to Chancellor Phyllis Wise.

Mitra earns AFOSR Young Investigator award

Jenny Applequist, ITI

CSL Professor Sayan Mitra has won a prestigious Young Investigator award from the Air Force Office of Scientific Research (AFOSR). Mitra's winning proposal was entitled "Verification Engines for Hybrid Networks."

His planned research aims to ensure the trustworthiness of complex distributed control systems, such as the onboard software that coordinates flight trajectories of groups of aircraft or unmanned aerial vehicles (UAVs) in order to guarantee that they remain a safe distance apart from each other.

Langbort wins NSF CAREER Award for information cloaking research

Susan Mumm, Aerospace Engineering

CSL Professor Cedric Langbort recently earned a National Science Foundation CAREER Award for a project that studies the effects of information cloaking as a means of defense against potential cyber-attacks.

The project, "A Dynamic Game Theoretic Approach to Cyber-security of Controlled Systems," involves designing control algorithms that manage the flow of information made available to a potential hacker.

The CAREER Award provides Langbort with $400,000 over five years to pursue his research.

Dominguez-Garcia named IEEE PES Outstanding Young Engineer

Tom Moone, ECE

The IEEE Power and Energy Society (PES) has named CSL Assistant Professor Alejandro Dominguez-Garcia the 2012 IEEE PES Outstanding Young Engineer.

Dominguez-Garcia's research interests lie in the interface of system reliability theory and control theory, especially as applied to power and energy systems. His work focuses on the impact that an increasing reliance on solar or wind power can have on the reliability of energy systems.

Lu receives CAREER Award

Elise King, CSL

CSL Assistant Professor Yi Lu has received a CAREER Award from the National Science Foundation for her work on dynamic scalability problems. The prestigious award recognizes junior faculty who "exemplify the role of teacher-scholars," according to NSF.

In addition, Lu and graduate student Qiaomin Xie recently won the Best Paper Award at the PERFORMANCE 2011 Conference for their paper, titled, "A Novel Load Balancing Algorithm for Dynamically Scalable Web Services."

Loui named editor of Journal of Engineering Education

Tom Moone, Electrical and Computer Engineering

ECE Professor Michael C. Loui has been named the new editor of the Journal of Engineering Education (JEE), the journal for the American Society for Engineering Education (ASEE). He will take over the editorial duties of the journal this summer.

"I am excited by the opportunity to serve as the editor of JEE, which is recognized globally as the premier journal for research on engineering education," said Loui, who is a researcher in the Coordinated Science Lab. "Working with ASEE and the broader engineering education community, I would seek to connect this research with practice, for the ultimate benefit of students."

IEEE Best Manipulation paper goes to Bretl, McCarthy

Kim Gudeman, CSL

CSL Assistant Professor Timothy Bretl and former ECE undergraduate student Zoe McCarthy have won the Best Manipulation Paper Award at the IEEE International Conference on Robotics and Automation. Their paper was chosen out of a record 2,032 submissions.

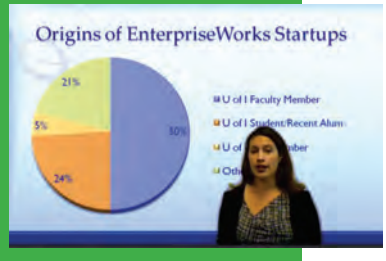
The paper, "Mechanics and Manipulation of Planar Elastic Kinematic Chains," provides a mathematical model for solving a problem that has mystified researchers for years: how to enable robots to manipulate deformable, or flexible, objects.

Nuvixa founders nab New Venture Award at Innovation Celebration

Video-solution company Nuvixa was honored with the New Venture Award at the 2012 Innovation Celebration, an event sponsored by the Champaign County Economic Development Corp. Nuvixa, headquartered in UI's Research Park, was started by CSL Professors Sanjay Patel, Minh Do and Wen-mei Hwu.

The company uses breakthroughs in computer vision, sensing and chip architecture to create novel video conferencing solutions, which enable users to insert themselves into presentations. Nuvixa has received considerable industry attention; AMD recently announced its investment in the company.

For more information, please visit nuvixa.com.



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Surveillance networks

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Seth Hutchinson (ECE) and Steven LaValle (Computer Science). Chung's expertise is in aerospace systems, autonomous systems, and robotics, including control of robots and high performance aerospace vehicles and formation of flying UAVs/MAVs and spacecraft. Hutchinson's interests are in robotics, vision and artificial intelligence, while LaValle is interested in the design of planning algorithms, mainly on problems involving continuous spaces, complicated geometric constraints, differential constraints, and/or sensing uncertainties.

Magnus Egerstedt, professor of Systems and Controls in the Georgia Tech School of Electrical and Computer Engineering, will work with the Illinois group. His interests include hybrid and networked control, with applications in motion planning, control, and coordination of mobile robots.

In a related project, Voulgaris and Associate Professor Dušan Stipanović recently received a 3-year grant from the Qatar National Research Fund to develop methods for safely coordinating networked vehicles. The overall grant is $950,000, with $320,000 commited to CSL research.

Researchers will work on developing algorithms that will guarantee safety in the presence of physical, collision avoidance and information constraints, and they will make the technology robust to communication uncertainty.

Safe and reliable multiple vehicle systems can be applied in numerous ways to benefit the oil and gas industry, making this technology important to Qatar's growth in that industry. This technology could be used in patrolling robots that sense dangerous leaks, such as H2S, coordinated fire extinguishing, coordinated oil spill cleaning and field coordinated surveillance.

This project, titled, "Smart Systems for Field Monitoring and Surveillance," will be done in collaboration with Professor Mansour Karkoub at Texas A&M University in Qatar. CSL researchers will focus on the methodologies and techniques, while Texas A&M Qatar will design and run the experiments.

Voulgaris said that this project is a "collaboration in a field that's new to us and can lead to further collaborations in bigger projects."

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The Information Trust Institute has launched its new virtual home at http://iti.illinois.edu. We hope you take a moment to check out the efforts currently underway to build trustworthy and secure information systems.

Part of the Coordinated Science Laboratory family, the Information Trust Institute is developing computer systems, software and networks in five major areas:

- **Data Science**
- **Evaluation**
- **Health Information**
- **Power Grid**
- **Systems & Networking**