Center for Embedded Systems for Critical Applications

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CESCA Newsletter
Center for Embedded Systems for Critical Applications

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In this edition:

CESCA Offices & Labs
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It's Time to Revitalize CESCA!

Congratulations on the inaugural issue of the CESCA newsletter!

A handful of faculty members scrambled together and proposed a research group in the summer of 2003 to be a part of the College's then new research center, ICTAS (Institute for Critical Technology and Applied Science). The proposal was successful, and CESCA was born in October 2003. Since then, CESCA has grown in size. Five new members, Profs Chao Huang, Leyla Nazhandali, Jung-Min Park, Patrick Schaumont, and Yaling Yang, have joined CESCA; meanwhile the founding four members, Profs. Lynn Abbott, Michael Hsiao, Sandeep Shukla, and myself, have added a few more grey hairs here and there.

The faculty members of CESCA have been active in their research since the inception of the research group. For example, five of its members are awardees of the NSF's Faculty Early Career Development (CAREER) award, which recognizes junior faculty who exemplify the role of teacher-scholars through outstanding research and education. Then, why should we go through the trouble of initiating with new CESCA activities such as the publication of newsletters, renovation of CESCA web pages, and writing joint proposals? The main driving force behind those activities was (and probably "is") the ECE department. The Department wanted the ECE faculty to form large research units and go after large research projects. Large projects, not only bring in more revenue to the Department, but enhance visibility of the Department and hence improve the department ranking. The Department's demand necessitated the CESCA faculty to collaborate further in research.

I joined VT in 1986 as a freshly minted new assistant professor, seven days after defending my Ph.D. dissertation. I have never been part of a large center at VT; in fact, at the time, there was no such organization in Computer Engineering. Although I have been moderately successful in my research and become an IEEE Fellow recently, I realize the limitations of individual faculty-driven research (as opposed to group-driven research), unfortunately 20+ years later. One may achieve moderate success alone, but not great success.

I see huge potential with CESCA faculty members. If we collaborate, we can make CESCA great. Based on my confidence on CESCA faculty's potential, I have set my career goal to make CESCA successful. Every CESCA member, student and faculty alike, should benefit from the success of CESCA. A simple example is staff support, which will liberate us from mundane tasks so that we can focus on our core missions. CESCA, like any other research center, started from humble beginnings but it continues its steady growth in terms of both size and significance. CESCA can be successful only when every member contributes in his/her capacity. Please help CESCA when you are called for. Nothing is too small to contribute to CESCA. Supply news items to CESCA newsletters, make suggestions to improve CESCA web pages; clean up your lab once in a while. The list can go on.

I dream for a day when CESCA is recognized as a world renowned research center. The dream can be achieved only through top quality research carried out by its faculty and students. As CESCA students, you should pursue excellence in your research and publish papers in top tier journals and conferences. As CESCA faculty, I believe our most important role is to support our students financially as well as academically. So our students can focus on their research without worrying about financial problems.

Striving for CESCA's success is a noble cause, but its success should not be based on sacrifices or exploitations of any CESCA members. Such an approach is like building a castle on sand, and we know it cannot sustain. Every CESCA member should receive due credit for his/her contribution to CESCA through research or by other means. Then, we can be proud of being associated with CESCA. I hope that all of you achieve great success under the auspices of CESCA. More importantly, I wish you enjoy being a constituent of CESCA. Also remember there is life outside work!

Before closing this preface, I would like to thank Yumi for her efforts that made this CESCA newsletter possible. Thank you.

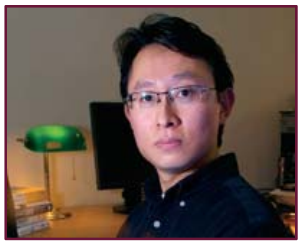
Dong Ha, Director of CESCA

Ha Collaborates Research with CIMSS

February 2009. Virginia Tech's Center for Intelligent Material Systems and Structures (CIMSS) directed by Prof. Dan Inman has teamed with Physical Acoustics Corporation (PAC), of Princeton Junction, NJ, to develop a suite of new technologies to provide a continuous, energy independent monitoring of the structural integrity of U. S. bridges. The National Institute of Standards and Technology (NIST) funds $14M for five years for the research, with Virginia Tech's share at about $2M. The research with Virginia Tech includes development of an innovative method for "harvesting" power from motions and vibrations in a bridge using piezoelectric materials, and Dong Ha's team is responsible for design of power conditioning circuits.

Two CESCA faculty Members featured in VT Annual Report 2007-08

Dr. Jung-Min Park



December 2008. Improving the security of cognitive radio technology is the goal of Virginia Tech College of Engineering researcher **Jung-Min Park**. Park, an assistant professor in the Bradley Department of Electrical and Computer Engineering, said that cognitive radio technology will be used for two-way communications in a wide range of applications, such as communication systems for tactical military forces and emergency responders. It also might be used in the development of wireless access networks that can provide Internet services to rural areas.align them with branded photography guidelines.

Dr.Sandeep Shukla

December 2008. Embedded computer work wins awards. Sandeep Shukla's work in designing, analyzing, and predicting the performance of electronic systems, particularly embedded compters, has drawn acclaim from the National Academies, the National Science Foundation, and the White House. Shukla has published more than 100 journal and conference papers and book chapters and has co-authored or co-edited three books. He is an associate editor of two Institute of Electrical and Electionics Engineers journals and has founded a new international journal on embedded software.

Research Trend in Energy Harvesting *(by Na Kong and Dong Ha)*

Thanks to development of low power VLSI circuits and systems, wireless and portable devices have brought in great convenience to people's daily life. However, limited charge capacity combined with bulky volume of batteries is the bottleneck for more compact and smarter wireless and portable devices. As an alternative or complement approach to improvement of batteries is to harvest energy from wasted ambient energy sources. The energy sources in the environment include, but are not limited to, solar, thermal, vibrations, and radio frequency (RF) radiation. The available power density of ambient energy sources is tabulated in the following table.

Typical amount of energy available for harvest [1, 2]

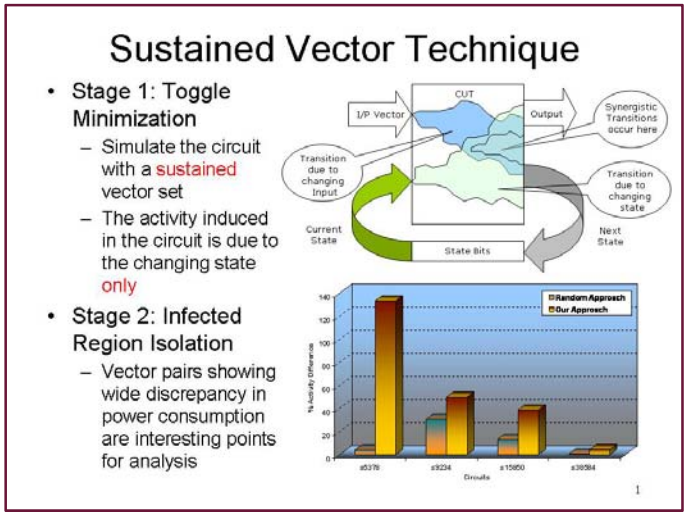
Sources	Conditions	Power density
Solar	Outdoor	100 $\mu W/cm^3$
Solar	Indoor	100 mW/cm^2
Thermal	T=5 ^oC	100 $\mu W/cm^2$
Vibration	1 m/s^2	60 $\mu W/cm^2$
RF	Unless near a transmitter	<1 $\mu W/cm^2$

Due to intermittence of ambient energy supply, the harvested energy is typically stored in an energy storage device such as a rechargeable battery or supercapacitor, before it is consumed by the load. A power conditioning circuit converts dynamic environmental energy into a stable power output for a storage device and adaptively maximizes the power extraction under varying operation conditions due to change of available energy to harvest or the load condition. The volumetric cost and power overhead of a power conditioning circuit is an important design consideration, which makes ASICs a promising solution. CESCA conducts research in power conditioning circuits in collaboration with CIMSS (Center for Intelligent Martial Systems and Structures) lead by Dan Inman.

References:
1. C. O. Mathuna, T. O'Donnell, R. V. Martinez-Catala, J. Rohan, and R. O'Flynn, "Energy scavenging for long-term deployable wireless sensor networks," *Talanta,* 75(3): 613-623, 2008.
2. J. A. Paradiso and T. Starner, "Energy scavenging for mobile and wireless electronics," *IEEE Pervasive Computing*, 4(1): 18-27, 2005.

Conference Papers of the Quarter

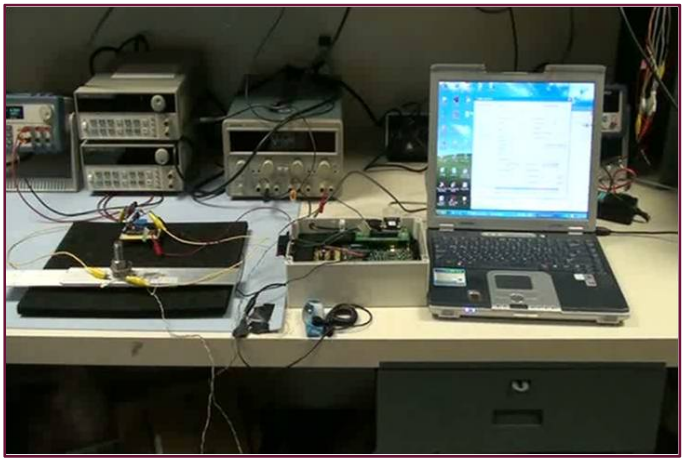
Paper Title: A Novel Sustained Vector Technique for the Detection of Hardware Trojans
Authors: Mainak Banga and Michael S. Hsiao
Conference: 22nd International Conference on VLSI Design, New Delhi, INDIA
Dates: Jan. 5th, 2009 – Jan. 7th, 2009



Abstract: Intentional tampering in the internal circuit structure by implanting Trojans can result in disastrous operational consequences. While a faulty manufacturing leads to a nonfunctional device, effect of an external implant can be far more detrimental. Therefore, effective detection and diagnosis of such maligned ICs in the post silicon testing phase is imperative, if the parts

are intended to be used in mission critical applications. We propose a novel sustained vector methodology that proves to be very effective in detecting the presence of a Trojan in IC. Each vector is repeated multiple times at the input of both the genuine and the Trojan circuits that ensures the reduction of extraneous toggles within the genuine circuit. Regions showing wide variations in the power behavior are analyzed to isolate the infected gate(s). Experimental results on ISCAS benchmark circuits show that this approach can magnify the behavioral difference between a genuine and infected IC up to thirty times as compared to the previous approaches.

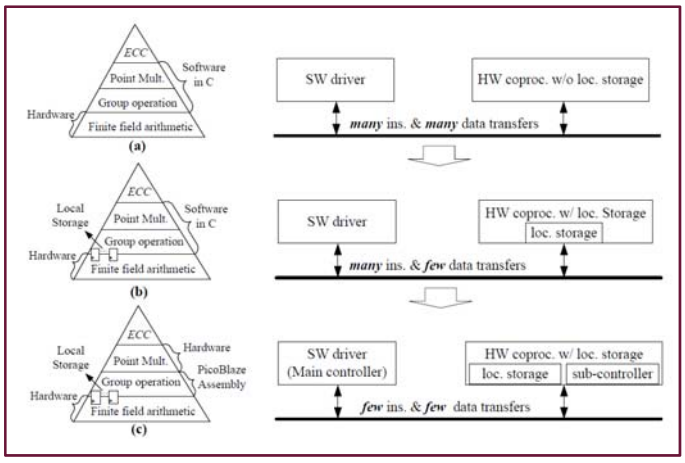
Paper Title: A Structural Health Monitoring System for Self-repairing
Authors: Jeong Ki Kim, Dao Zhou, Dong S. Ha, and Daniel Inman
Conference: SPIE International Symposium on Smart Structures and Materials & Nondestructive Evaluation and Health Monitoring, San Diego, USA
Dates: March 9th, 2009 – March 12th, 2009



Abstract: Shape memory alloy (SMA) washers expand axially when heated, and the expansion for the one-way type SMA is permanent even if the heat is removed. We investigated a method to repair bolted joint loosening defects using SMA washers. We incorporated such a feature into our impedance-based structural health monitoring (SHM) system. An SMA washer wrapped with a heater is installed between a bolt and the nut. Upon detection of a loosening defect, the heater is turned on to expand the SMA washer, which in turn repairs the defect. Our experimental results show that (i) our enhanced SHM system can detect bolted-joint loosening defects, and (ii) it can repair such defects effectively. Our system suggests that self-repairing of some structural defects is feasible without human interventions.

Paper Title: Optimizing the Control Hierarchy of an ECC Coprocessor Design on an FPGA based SoC Platform
Authors: Xu Guo and Patrick Schaumont
Conference: 5th International Workshop on Applied Reconfigurable Computing, Karlsruhe, Germany
Dates: March 16th, 2009 – March 18th, 2009

Abstract: Most hardware/software codesigns of Elliptic Curve Cryptography only have one central control unit, typically a 32 bit or 8 bit processor core. With the ability of integrating several soft processor cores into one FPGA fabric, we can have a hierarchy of controllers in one SoC design. Compared to the previous codesigns trying to optimize the communication overhead between the central control unit and coprocessor over bus by using different bus protocols (e.g. OPB, PLB and FSL) or advanced techniques (e.g. DMA), our approach prevents overhead in bus transactions by introducing a local 8 bit



System architecture modeling of different schemes

microcontroller, PicoBlaze, in the coprocessor. As a result, the performance of the ECC coprocessor can be almost independent of the selection of bus protocols. To further accelerate the Uni-PicoBlaze based ECC SoC design, a Dual-PicoBlaze based architecture is proposed, which can achieve the maximum instruction rate of 1 instruction/cycle to the ECC datapath. Using design space exploration of a large number of system configurations of different architectures discussed in this paper, our proposed Dual-PicoBlaze based design also shows best trade-off between area and speed.

CESCA Seminars (Jan.1, 2009 – March 31, 2009)

Synthetic Aperture Radars (SARs) for Remote Sensing Applications
Speaker: Prof. Min-Ho Ka / Department of Electronic Engineering / Korea Polytechnic University, Korea
Date: Feb. 13, 2009

Abstract: A Synthetic Aperture Radar (SAR) with aid of other instruments for remote sensing can collect valuable data for various scientific and civil applications such as ocean surface monitoring, sea state measurements, ice studies, land surface relief imaging, level monitoring of large inland waters as well as defense applications. Several research projects have been conducted recently at Radar Remote Sensing Laboratory of Korea Polytechnic University in collaboration with Korean and international firms, and we present major research findings of the projects as well as some basic operations of SARs.

Prediction of Fall-Prone Elderly
Speaker: Prof. Thurmon Lockhart / Industrial Systems Engineering
Date: Jan. 30, 2009

Abstract: Variability in kinematic and spatio-temporal gait parameters has long been equated with stability and used to differentiate fallers from non-fallers. Recently, a mathematically rigorous measure of local dynamic stability has been proposed based on the nonlinear dynamics theory to differentiate fallers from non-fallers. A typical biomechanical perturbation study will be discussed in light of whether the assessment of local dynamic stability can identify fall-prone elderly individuals who were unable to successfully avoid slip-induced falls. Results will be discussed providing evidence that the increased falls of the elderly may be due to the inability to attenuate/control stride-to-stride disturbances during locomotion, and using local dynamic stability as a potential indicator of risk of falling.

Upcoming Event

- CESCA seminar, Prof. Dennis Hong, April 17 (Friday), Research on Mobile Robots

Recent Publications (Jan. 1, 2009 – March 31, 2009)

January

- Mainak Banga and Michael S. Hsiao, "A novel sustained vector technique for the detection of hardware trojans," *IEEE International VLSI Design Conf*., January 2009, pp. 327-332.
- Y. Zheng and C. Huang, "A novel Toffoli network synthesis algorithm for reversible logic," *Asia & South Pacific Design Automation Conf. (ASP-DAC),* January 2009.

February

- B. MacKenzie, J. H. Reed, P. Athanas, C. W. Bostian, R. M. Buehrer, L. A. DaSilva, S. Ellingson, Y. T. Hou, M. Hsiao, J. Park, C. Patterson, S. Raman, and C. da Silva, "Cognitive Radio and Networking Research at Virginia Tech," *Proceedings of the IEEE*, February 2009.
- A. Maiti, P. Schaumont, "Impact and Compensation of Correlated Process Variations on Ring Oscillator Based PUF," poster presentation, *17th International Symposium on Field Programmable Gate Arrays (FPGA 2009),* February 2009.
- N. Kong, A. Davoudi, M. Hagen, E. Oettinger, M. Xu, D.S. Ha, and F.C. Lee, "Automated System Identification of Digitally-Controlled Multi-phase DC-DC Converters," *Applied Power Electronics Conference and Exposition*, pp. 259-263, February 2009.

March

- D. Zhou, J.K. Kim, D.S. Ha, J.D. Quesenberry, and D.J. Inman, "A System Approach for Temperature Dependency of Impedance-Based Structural Health Monitoring", *SPIE International Symposium on Smart Structures and Materials & Nondestructive Evaluation and Health Monitoring*, (10 pages), March 2009.
- J.K. Kim, D. Zhou, D.S. Ha, and D.J. Inman, "A Structural Health Monitoring System for Self-repairing", *SPIE International Symposium on Smart Structures and Materials & Nondestructive Evaluation and Health Monitoring*,(8 pages), March 2009.
- J.K. Kim, D. Zhou, D.S. Ha, and D.J. Inman, "A Practical System Approach for Fully Autonomous Multi-Dimensional Structural Health Monitoring", *SPIE International Symposium on Smart Structures and Materials & Nondestructive Evaluation and Health Monitoring*, (10 pages), March 2009.
- X. Guo, P. Schaumont, "Optimizing the Control Hierarchy of an ECC Coprocessor Design on an FPGA based SoC Platform," *5th International Workshop on Applied Reconfigurable Computing (ARC2009), LNCS5453*, pp.169-180, Springer Verlag, March 2009.

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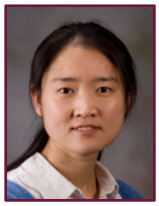

Yaling Yang