EEDNNEET

ISSN 2010-1651 = JULY 2011 = ISSUE 3

A BI-ANNUAL PUBLICATION OF THE DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

THE OPTICAL MICROSCOPE IS ONE OF THE MOST IMPORTANT SCIENTIFIC ACHIEVEMENTS IN THE HISTORY OF MANKIND.



IT WAS THE YEAR PAGE 2001 WHEN NUS ECE SELECTED A SRI LANKAN UNDERGRADUATE WHO HAD BEEN RANKED 5TH IN THE GCE A-LEVEL EXAMINATION.



AN NUS ECE TEAM CONSISTING OF STUDENTS SUPERVISED BY PROF BEN M CHEN AND PROF LEE TONG HENG WON BIG TIME AT THE SINGAPORE AMAZING FLYING MACHINE COMPETITION 2011 (SAFMC) HELD ON 18 MARCH 2011.



INAUGURAL PROFESSORIAL LECTURE GETS UNDER WAY



PAGEECE DEPARTMENT STARTED ITS INAUGURAL
PROFESSORIAL LECTURE SERIES TO ENABLE NEWLY
PROMOTED FULL PROFESSORS IN ECE TO ADDRESS
A LARGE AUDIENCE OF COLLEAGUES, STUDENTS
AND INDUSTRY.

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Assoc Prof Teo Kie Leong
Assoc Prof Marc Andre Armand
Ms Winnie ChuaPhotographyMr Abdul Jalil Bin DinAdvisorProf Chua Kee Chaing

HoD SPEAKS....

No doubt, with the economic outlook for ECE graduates continuing to look bright with the robust growth of the electronics industry, it is a good time to embark on a meaningful career.

Prof **Chua** Kee Chaing Head, Department of Electrical & Computer Engineering, NUS

In the past six months, we have been getting new core and elective modules that students will read in their later years of our BEng(EE) programme ready. We have also made some significant changes to our graduate programmes. These changes, recently approved by the University's Board of Graduate Studies, included increasing the number, scope and depth of our 6000 level modules, improving on a number of processes in PhD student advising and training, and consolidating our MSc module offerings. These will be implemented in the new academic year beginning August 2011.

In research, we have increased collaboration with A*STAR's Institute for Microelectronics (IME) and Data Storage Institute (DSI), participating in key thematic programmes in Future Data Centre Technologies, GaN-on-Si, and Ruggedized Electronics. Riding on these collaborative research efforts, we have also started thematic PhD programmes with IME and DSI on Power Semiconductor and Future Data Centre Technologies, respectively. Students in these thematic PhD programmes will be jointly supervised by ECE faculty and IME/DSI researchers, and will present their research results to industry regularly.

Our outreach efforts continue apace, with many activities such as the Electronics for the Community project highlighted in this issue. We have recently started to raise funds for an ECE Scholarship programme to offer a limited number of bond-free scholarships to attract top local students to our programmes. So far, we have raised more than \$60,000 just from ECE colleagues alone. We will need at least \$200,000 to start the scholarship programme.

A number of our colleagues and students have done well and won awards. Some of these are highlighted in this issue. We are especially proud of our teaching award winners: A/Prof Dipti **Srinivasan**, Prof **Lian** Yong and Prof **Lee** Tong Heng; and our Chair Professors: Prof Lian Yong (Provost's Chair), A/Prof Mansoor **Jalil** (Dean's Chair) and Dr **Yeo** Yee Chia (Dean's Chair). Our heartiest congratulations to them!

It is again Commencement time, and our Electrical and Computer Engineering classes of 2011 will be graduating. On behalf of everyone at NUS/ECE, I congratulate them on their fine achievements. No doubt, with the economic outlook for ECE graduates continuing to look bright with the robust growth of the electronics industry, it is a good time to embark on a meaningful career.

INAUGURAL PROFESSORIAL LECTURE GETS UNDER WAY

ECE Department started its Inaugural Professorial Lecture Series to enable newly promoted full professors in ECE to address a large audience of colleagues, students and industry. The first professorial lecture, *Expanding the Frontiers of Biomedical Circuits & System*, was presented on 8 March 2011 by Professor Lian Yong.

Prof Lian Yong is a Fellow of IEEE, a Provost's Chair Professor and Area Director of Integrated Circuits and Embedded Systems in the Department of Electrical & Computer Engineering at the National University of Singapore. His research interests include low power circuit techniques for biomedical devices, signal processing and biomedical system-on-chip. He has published over 160 papers in peer-reviewed journals and conference proceedings, and has received many awards for his research works. Prof Lian is the Founder of *ClearBridge VitalSigns* Pte Ltd, a start-up for wireless wearable biomedical devices. He is also a recipient of the 2009 and 2010 NUS Annual Teaching Excellence Award.

In his lecture, Prof Lian presented previous works and ongoing studies at NUS to reveal novel circuit and signal processing techniques that can help shape future health care. In particular, he presented a wireless Body Sensor Network (BSN) platform, which can be used for wireless biomedical sensors around or inside a human body to provide personalised and prevention-oriented health care. The BSN, combined with wearable, ingestible, injectable, implantable biomedical devices, allows for the continuous or intermittent monitoring of physiological signals, and is critical for the advancement of both diagnosis and treatment.



A friendly chat before the lecture

INAUGURAL PROFESSORIAL LECTURE Expanding the Frontiers of Biomedical Circuits & Systems

Prof. Yong LIAN, IEEE Fellow Provost's Chair Professor Area Director, Integrated Circuits and Embedded Systems Editor-in-Chief, IEEE Transactions on Circuits & Systems II Founder, ClearBridge VitalSigns Pte Ltd

> Faculty of Engineering Department of Electrical & Computer Engineering

A man of many hats

NUS



Rounding up the lecture

DR STEVEN ZHOU HONOURED FOR HIS PIONEERING AND ENTERPRISING EFFORTS IN MIXED REALITY

Asst Prof Steven **Zhou** Zhiying received the inaugural Outstanding NUS Innovator Award at the Enterprise Connection Dinner. The award was an initiative by NUS Enterprise and the NUS Society and was supported by the National Research Foundation's University Innovation Fund. The judging panel was impressed not only by Dr Zhou's notable achievements in his research on augmented reality but also by his entrepreneurial spirit, which he has demonstrated in founding MXR Corporation Pte Ltd. His company develops patented Mixed Reality products for Next Generation Learning and provides Mixed Reality technological solutions. By using Mixed Reality technology, MXR Corporation successfully commercialised the world's first education product for children, wlzQubes™.

Dr Zhou is also Director of the Interactive Multimedia Lab at NUS ECE. He is known for his contributions in Mixed Reality, human–computer interaction, computer vision, mobile computing and multimodal systems. A Fellow of World Technology Network, his work has garnered numerous awards, including the RTT Emerging Technology Award 2008 and the SiTF Award 2010 in Digital Media.



Dr Steven Zhou (right) receiving the inaugural Outstanding NUS Innovator Award from NUS President, Prof Tan Chorh Chuan

NEW APPOINTMENTS AND PROMOTIONS

FACULTY APPOINTMENTS

We welcome the following new members into our ECE family.

- DR LIM TENG JOON joined ECE Department on 1 June 2011 as Full Professor. Prior to joining ECE
 Department, Prof Lim was a tenured Full Professor at the University of Toronto, Canada from 2000 to 2011.
 Prof Lim obtained his PhD in 1995 from the University of Cambridge, UK. His research spans a range of topics
 in communication theory and includes notably, the design and analysis of power-and bandwidth-efficient
 wireless networks of multiple users.
- DR AKASH KUMAR joined ECE Department on 1 June 2011 as Assistant Professor. He first joined ECE
 Department on 1 July 2009 as a Visiting Fellow. He graduated in 2009 with a PhD degree jointly offered by NUS
 and Eindhoven University of Technology. Dr Kumar's research focuses on embedded systems, more specifically in
 the areas of predictable multi-processor systems in terms of architecture and applications.
- DR ZHAO QI joined ECE Department on 1 June 2011 as Assistant Professor. Prior to joining ECE Department, she was a postdoctoral researcher in Computation and Neural Systems and Division of Biology at the California Institute of Technology, USA. Dr Zhao graduated with a PhD degree from the University of Santa Cruz, USA in 2009. Her research interests are in the areas of computational visual cognition, neuromorphic visual models and systems, computer vision and statistical learning, and computational neuroscience.
- DR PANG SZE KIM joined ECE Department on 1 December 2010 as Adjunct Assistant Professor. He is a Senior Member of Technical Staff at DSO National Laboratories. His research interests are in the areas of signal processing and Bayesian statistics. Dr Pang obtained his PhD in 2009 from the University of Cambridge, UK.

- DR GAN OON PEEN joined ECE Department on 1 February 2011 as Adjunct Associate Professor. He is Group Manager of the Manufacturing and Execution Control (MEC) Group at the Singapore Institute of Manufacturing Technology (SIMTech), A*STAR. His research is mainly in the areas of RFID middleware, track and trace, ad hoc networking, intelligent control, distributed networks, embedded systems, operation research and industrial automation. Prof Gan obtained his PhD in 1997 from the National University of Singapore.
- DR SUSANTO RAHARDJA joined ECE Department on 14 April 2011 as Adjunct Full Professor. He is Head of the Signal Processing Department and also Director of Research at the Institute for Infocomm Research (I²R), A*STAR. His research is mainly in the areas of digital audio and signal processing. Prof Rahardja obtained his PhD in 1997 from Nanyang Technological University, Singapore.

TEACHING ASSISTANTS

- MS CHUA DINGJUAN assumed duty as Teaching Assistant on 19 January 2011.
- MS **DO** THI THU TRANG assumed duty as Teaching Assistant on 1 February 2011.

ADMINISTRATIVE APPOINTMENTS

- MS LEENA D/O NAKULAN was appointed Assistant Manager, ECE Department on 1 March 2011. She handles the graduate (research) student admission and scholarship portfolio in the Department.
- MS PANDIARASI D/O **KARUPPIAH** joined ECE Department as Management Assistant Officer on 9 May 2011.
- MS KOH XIN AI joined ECE Department as Management Assistant Officer on 3 June 2011.

ADMINISTRATIVE PROMOTIONS (from 1 January 2011)

- MS EUNICE WONG YOKE CHENG Manager
- MS HELENE YAO Manager
- MS MARSITA BTE SAIRAN Management Assistant Officer (Grade 2)
- MR ERIC POON WAI CHOONG Lab Technologist (Grade 3)

ELECTRONICS FOR THE COMMUNITY: EASY-TO-USE INNOVATIONS FOR THE ELDERLY

An outreach effort by the ECE Department has resulted in innovations for the elderly. It has proven to be meaningful as well as fun for the upper secondary and JC students who were involved in the project.

The two-year-old programme, jointly organised with the Southwest Community Development Council (Southwest CDC), Agilent Technologies and River Valley High School (RVHS), focuses on simple but innovative gadgets to help the elderly in their daily lives.

A group of 60 students from different schools interviewed the elderly in rental blocks at Boon Lay to find out more about the problems they were facing in their daily lives. They also identified those who might need help, and offered electronic solutions for them. The students presented their efforts at a competition on 15 January 2011 and displayed their innovations at the "Safe and Bright Home", a community event organised by Southwest CDC, which was graced by the mayor, Dr Amy **Khor**.

RVHS student **Chew** Yingying and her team won the first prize with their medication reminder system, which targeted the elderly living on their own. Said Yingying: "Our group has benefitted from the project in many intangible ways: we now appreciate the little things that we are fortunate to have, we have been very motivated and we have learnt to work with responsibility. Above all, we now communicate better with our elders as we are able to empathise more." The medication reminder system looks like a miniature version of the medicine chests you see at traditional Chinese medicine shops.

Each tiny box contains the pills that the user needs to take for the day. A voice will sound a reminder from the right box when it is time for the user to take his or her medicine. The system can be more effective and personalised, as the "voice" could be that belonging to a loved one. RVHS



The RVHS team explained the function of their medication reminder system to Dr Amy Khor

project co-ordinator, Mr **Xu** Weiming, said they are keen to continue with the programme: "The students thoroughly enjoyed the experience and found meaning and significance in applying science and technology to help the greater community. They have also learnt important life skills in communicating with people from diverse backgrounds, empathy and key considerations in designing solutions to help the elderly. The programme has given them ample opportunities to think critically and practically. On top of that, the exposure has demonstrated the capabilities of electronics solutions. This is indeed an invaluable experience for the students."

Chia Jiaying of Cedar Girls Secondary School shared: "The project has allowed every participant to grow and learn. We have picked up skills that we can apply in daily life. The project exposed participants to the world of electrical engineering very effectively. It has opened our eyes to the plight of the elderly in our community and strengthened our conviction to help them. As the leader of my team, I learnt even more. Our project was not the best compared to other teams, but I learnt that it is not just the result that counts. What matters is the progress and growth we achieved, both as individuals and as a group."

"All the gadgets they have invented are in ready-to-use state. The technologies behind them are not new. But the students have thought of ingenious ways to redesign and package them so that they are really low cost, and easy and convenient to use," said Assoc Prof **Tan** Kok Kiong, ECE co-ordinator and mentor for the project.

Other prototypes resulting from the students' ideas include the following:

Night lights and warning windows

Running on low voltage and using solar energy generated from panels on the roof of HDB flats, these LED-embedded windows become an instant light source. Red warning lights framing the windows are activated if a house occupant falls or is in some kind of difficulty. These windows can also be modified to warn the occupant of other dangers such as fire or earthquake.



This looks like and weighs the same as a normal watch but it comes with modular assistive functions such as distress alert mechanics, a GPS tracker allowing the elderly with dementia to go safely beyond the confines of their home, and an embedded low-cost hearing aid for those with hearing disability.





PROBING THE WORLD OF SIGNALLING AND COMMUNICATIONS THROUGH EE1003

A compulsory new module (EE1003) introduced by ECE has very much broadened the learning experience of some 180 first-year students in the field of laser communication. Under the guidance of three lecturers, Prof **Kam** Pooi Yuen, Assoc Prof Marc Andre **Armand** and Dr **Zhang** Jianwen, the students were divided into groups to build a system converting analogue signals to digital signals and then transmitting these signals by using laser links.

This sounded like a tall challenge for these first-year students, who had never done anything like this before. However, they tackled the problem with gusto and enthusiasm. They were surprised to discover that a common everyday laser pointer was the solution to one of their biggest challenges! The module has also shown that students without much advanced technical knowledge can build real-world communication systems and that they can grasp important basic communication concepts.

Dr Zhang explained: "We needed a laser beam to carry information to the receiver and a laser pointer is excellent for this. It has a lot of advantages in transmitting signals, which are clearer with less interference. Laser transmission also does away with messy wirings and cablings."

The project not only led students into the intriguing world of learning all about circuits, signals and communication but also challenged each member to grow and learn as a team.

Poh Wei Jin, a group leader who was previously from Tampines Junior College, said, "We started about one and a half months ago. As my team has a mix of local and international students, we needed to develop good chemistry among ourselves so that we would accept each other's ideas. I also needed to know the strengths of my members. In the end, we worked well together and, although we were given two schemes to base our projects on, we came up with a 'third' scheme, which we developed on our own. Overall, it was a very good experience for all."

Last year, the students successfully designed and built an autonomous car model for the inaugural module, EE1002. Assoc Prof **Loh** Ai Poh, Deputy Head for Undergraduate Programmes at the Department, said at the introduction of the compulsory new modules last year that they would help motivate students to learn in a deeper way when they eventually embarked on the core curriculum. In the process of conceptualising, designing and completing their projects, the students would have done a lot of problem solving. They would also be more motivated to learn the underlying theories after experiencing how a communication system actually works. Wei Jin already has ideas for developing a home Bluetooth sound system, where music can be played from one source and enjoyed by all members wherever in the house they may be.



EE1003 in full swing at ECE's Digital Systems & Applications Lab



From left: Tang Buu Vinh, Poh Wei Jin, Nguyen Anh Tuan and Nguyen Phan Minh. They challenged themselves and came up with various out-of-the-box concepts



Laser communication in progress, transmitting strong and clear signals from a microphone to user point, which for some groups is 10 metres away

GETTING TO KNOW DR ZHANG RUI

Dr **Zhang** Rui joined ECE Department last year and readily agreed to take this opportunity to introduce himself to the ECE family.



Tell us about yourself.

A I was born in Changchun, the capital city of Jilin Province, in the north-eastern part of China. When I was 16 years old, my family and I moved to Nanjing (meaning, "south capital" of China) in Jiangsu Province. There, I spent three years attending senior high school at Middle School Affiliated to Nanjing Normal University, one of the most famous secondary schools in China. Mathematics and physics have always fascinated me. In fact, I received several awards in national competitions in these areas, including First Prize Award at the National Physics Competition in 1994.

My passion for the two subjects paved the way for a promising education. In 1995, I was admitted to Zhejiang University of China without taking the national entrance exam. I was selected to attend the "Mixed Class", a special programme open to the top 5% of all the first-year students majoring in engineering and science. In the same year, I received a scholarship from MOE, Singapore. Then my undergraduate study at NUS ECE began in 1996. I was enrolled under the Accelerated Master Programme, which allowed me to complete my BEng (in which I received first-class honours) and MEng degrees in just four and a half years. After that, I worked for about one year at NUS ECE as a full-time teaching assistant.

In 2002, I received the National Science Scholarship (NSS) of Singapore from NSTB (now A*STAR), enabling me to pursue my PhD study in the Department of Electrical Engineering at Stanford University, USA, specialising in information and communications engineering. I worked in the Dynamic Spectrum Management Laboratory under the supervision of Prof John M. **Cioffi**, who is recognised worldwide as the "Father" of DSL technology. Besides research, I enjoyed taking about 30 classes at Stanford, which covered subjects ranging from communications, signal processing and information theory to mathematics (convex optimisation and probability theory in particular).

After my graduation from Stanford, I returned to Singapore in 2007 and joined the Institute for Infocomm Research (I²R) of A*STAR. From 2007 to 2009, I worked in a research team at I²R on cognitive radio, which is a new and promising technology for next-generation wireless communications. The team has made significant contributions in this area, and our research outcomes are now widely recognised in the community.

Do you have any memorable experiences to share from your BEng and/or MEng days at ECE?

A I enjoyed my studies at NUS ECE very much. I benefitted from attending many excellent classes conducted by immensely knowledgeable and responsible professors. I can still remember how I struggled as a third-year undergraduate student in Prof **Kam** Pooi Yuen's EE4 class on digital communication. But the experience was rewarding. Later, what I learnt from his class proved to be extremely useful in my research career. Among many others, I am particularly grateful to the late Prof **Tjhung** Tjeng Thiang for his invaluable guidance. He acted as main adviser of my theses in both final and master years. Sincere gratitude is also due to Prof **Yeo** Swee Ping, who encouraged me to apply for an NSS scholarship. It made my dream of studying at Stanford a reality.

Q Multiple paths are available to A*STAR scholars. Was choosing the Academia Pathway an easy decision? Who influenced you to choose this path?

A Becoming a successful academician in a worldrenowned university such as NUS has been my dream for many years. This motivated me to start my academic career in 2010 under the A*STAR-NUS Joint Appointment Scheme. But being one of the very first to try out a new scheme, I experienced moments of uncertainty. However, strong encouragement from Prof **Chua** Kee Chaing (HoD, ECE) and Prof **Lye** Kin Mun (ED, I²R) dissipated any doubt and hesitation that I felt in taking the course.

Q What are your research interests? What projects are you currently working on?

A I have a wide range of interests in communications, signal processing, convex optimisation and information theory. Over the past several years, my research has focused on the design and performance optimisation of wireless communication systems (e.g. cellular networks) with advanced physical-layer transmission technologies, such as multi-antenna signal processing, cooperative communication and cognitive radio. To date, my research outputs have been published in more than 100 internationally refereed journals and conference papers. Currently, I am continuing my research in these areas, exploring new promising areas of wireless communications research related to energy issues, such as energy efficiency and energy harvesting.

A CHIT-CHAT WITH DR AKSHAY RATHORE

Rell us about yourself.

A I was born to a family of teachers and was brought up in India. I received my schooling and Bachelor's degree in Electrical Engineering in Rajasthan, a northern state that is well known for its rich culture and history.

My undergraduate years saw my avid involvement in student politics. I was College President of the Engineering Students Association and Chairman of the Electrical Engineering Students Society. In addition, I organised several cultural functions, youth festivals, entrepreneurship camp and IT workshops, to name a few.

I obtained my Master's degree in Technology (MTech) with specialisation in Electrical Machines and Drives from Banaras Hindu University, Varanasi. There, I immersed myself in modelling, analysing and controlling linear induction motors. I also participated in IET (UK) and IEEE (USA) chapter activities, organising national-level paper presentations and technical-project competitions. My hard work paid off when I was awarded a gold medal for achieving the highest academic standing among all electrical engineering students. Then, after the course, I spent a year and a half as a lecturer in India.

I finished my PhD in power electronics at the University of Victoria, BC, the most beautiful area in the island of Victoria, Canada. In addition to education and research, the institution is recognised for its green campus and great summer activities. During those years, I worked on a high-frequency soft-switching DC/DC converter and an inverter for fuel cell-based applications, particularly single-phase grid interface and residential functions. The 13 publications on the analyses, design and control of power converters from my PhD research were testament to my work's progress. After the course, I lectured in two undergraduate classes for two semesters.

Why did you choose Singapore and NUS ECE?

A I chose Singapore not only because it is a beautiful and developed country but also because it is a place close to home. ECE@NUS, on the other hand, is world renowned and highly ranked for its innovative research contributions in broad areas of engineering. I was always inspired by ECE@NUS, and I consider it my work location of choice.

How are you settling in Singapore?

A Quite fast! The country offers the same facilities, prompt services and fast life as North America. However, I do miss the brand of shopping and customer service in the United States and Canada.



Please share your research.

I enjoy designing and developing converter topologies and their hardware implementation. My PhD research project entitled "High-frequency Transformer Isolated Power Conditioning System for Fuel Cells to Utility Interface" was sponsored by the Natural Sciences and Engineering Research Council of Canada. Within four years of PhD study, I worked on the interfacing schemes for connecting PV/Fuel cells to single-phase utility lines; the analysis and design of soft-switching, current-fed topologies; the small-signal analysis and closed-loop control of current-fed converters; and a multistage inverter for residential applications. I developed the hardware of 1-kW, current-fed converters and three-stage inverters and tested these in a research lab, along with closed-loop controllers, at a switching frequency of 100 kHz.

WEG, Brazil, a leading multinational drives company, supported my first postdoctoral research in Germany, entitled "Optimal Modulation of Multilevel Inverters". Through this research, I developed a software programme generating optimal switching angles resulting in low harmonic distortion and high efficiency at low switching frequency. WEG successfully tested this new technology for a 5-kV, MW drive at a switching frequency of 200 Hz.

The National Science Foundation and the Department of Energy sponsored my second postdoctoral study in the United States. This gave me the opportunity to work on three-phase inverters for PV and fuel cell applications. Further, I gained sufficient exposure to the hardware of silicon carbide MOSFETs, nanocrystallinecore transformers, silicon carbide schottky diodes, and low-resistance semiconductor devices such as OptiMos and DirectFET.

At present, I am working on a smart, hybrid residential energy system. However, I also see myself venturing into the areas of electric and fuel cell vehicles and energy storage in the future.

What are your hobbies?

A lenjoy watching Bollywood movies and cricket, listening to Hindi and folk music and songs, playing chess and cricket, and engaging in online social networking activities.

MICROSPHERE NANOSCOPE TO SEE OBJECTS AT 50 NANOMETRES

The optical microscope is one of the most important scientific achievements in the history of mankind. It has revolutionised the life sciences and still remains indispensable in many areas of scientific research today. However, due to the optical diffraction limit, the imaging resolution of a classical optical microscope is limited to around 1 micrometre. In nanotechnology and biology research, viewing objects in nanoscale is pursued consistently by researchers.

A research team from the National University of Singapore (Assoc Prof **Hong** Minghui, Mr **Chen** Zaichun), Data Storage Institute (Prof Boris **Luk'yanchuk**) and Manchester University (Dr **Wang** Zengbo, Mr **Guo** Wei, Mr Ashfaq **Khan**, Prof **Li** Lin and Prof **Liu** Zhu) envision "microsphere nanoscope", which can see 50 nanometres (20 times smaller than the conventional microscope) under white light. The invention breaks the theoretical limit of an optical microscope. The research results were published in *Nature Communications* (http://www.nature.com/ncomms/archive/date/2011/03/index.html) in March 2011.

The microsphere nanoscope, combining microspheres into a conventional microscope, provides a way to flexibly modify the microscope to achieve a resolution at 50 nanometres. Firstly, the technique makes use of the dielectric microspheres on top of the samples to collect "evanescent waves" in near field and refocuses them into a virtual image. The virtual image is then amplified by a standard optical microscope into a far field, which breaks the optical diffraction. Secondly, the microsphere nanoscope can operate in white light across the whole visible spectrum. Thirdly, the microsphere nanoscope can work in both transmission and reflection modes.

The microsphere nanoscope provides new opportunities to see cells, bacteria and even viruses in real time. If successfully commercialised, it would be a low-cost component in enhancing the performance of existing microscopes.



Microsphere nanoscope imaging in transmission mode



Microsphere nanoscope imaging in reflection mode

ENABLING COMPONENTS FOR NEXT-GENERATION WIRELESS APPLICATIONS: 60-GHZ CMOS POWER AMPLIFIER

Millimetre-wave wireless technologies are very promising for multi-gigabit communication systems, high-resolution imaging, sensing and detection. The worldwide opening of unlicensed spectrum of around 60 GHz in massive amounts has triggered great interest in developing affordable 60-GHz radios. A team led by Asst Prof **Guo** Yongxin has been developing novel techniques to solve the issues in CMOS power amplifier for 60-GHz radios. The team's work has received an international Best Student Paper Award.



Figure 1: The applications of 60-GHz radios include (a) consumer electronics: HDTV and video streaming, (b) PC and peripherals: WUSB, (c) gaming and mobile phones: video download, and (d) bulk file transfer

A power amplifier dominates the transceiver's performance in terms of its output power, gain and efficiency. The high frequency applied and the low voltage supplied by the submicron CMOS process have become obstacles to achieving high gain and output swing. Dr Guo's team has been doing research in silicon-based, millimetre-wave power amplifiers.

The 60-GHz unilateralised CMOS differential amplifier by Xiaojun **Bi**, Yongxin Guo, James **Brinkhoff**, Mook-Seng **Leong** and Fujiang **Lin** won the Best Student Paper award in the International Conference on Microwave and Millimeter-Wave Technology 2010, China. Jointly with Institute of Microelectronics (IME, A*STAR), Dr Guo's team created a general criterion for judging unilateralisation in a differential amplifier and developed a unilateralised, 60-GHz CMOS power amplifier in a 90-nm CMOS, as shown in Figure 2. By using a four-port feedback network, the amplifier can simultaneously obtain gain and stability improvement within a millimetre-wave band. The amplifier achieves an output 1dB compression point of +5.1 dBm, Psat of +8.5 dBm and 7.7% peak PAE while drawing 53 mA from a 1-V supply, as shown in Figure 3.



Figure 2: 60-GHz power amplifier in CMOS



Figure 3: Measured S-parameter and power performance

Besides the work mentioned above, Dr Guo's team has also been working on (a) high-efficiency chip and package-level integrated antennas for wireless communications and biomedical applications, and (b) modelling, characterisation and design of highefficiency, high-power microwave and millimetre-wave devices based on GaAs and GaN on SiC. His proposal on integrated antenna systems received the 2009 NUS Young Investigator Award.

PROF WANG QING-GUO'S PAPER WON THE TOP PLACE OF CITATIONS FOR AUTOMATICA 2006-2010

Prof **Wang** Qing-Guo and his research fellows' research article entitled "Delay-range-dependent stability for systems with time-varying delay", published in Automatica, Vol 43, No. 2, 2007, won the top place in terms of citations among all the papers published in the journal during 2006–2010. Christopher **Greenwell**, Publisher for Control and Signal Processing, Elsevier Ltd, says, "The citation data was taken from Elsevier's citation and bibliographic database SCOPUS (www.scopus.com). I have looked at the top 10 articles in terms of citations, and your article is indeed the top one for the years 2006–2010". Automatica is one of the two best journals in the control area. The other is IEEE Transactions on Automatic Control.

This most-cited paper investigated the stability analysis of systems with time-varying delay in a range. Its key contribution is a novel construction of a new type of Lyapunov functional. The authors estimate the upper bound of the derivative of the Lyapunov functional without ignoring some useful terms, and introduce additional terms into the Lyapunov functional, which take into account the range of delay. This enables them to establish improved stability conditions that are delay dependent and much less conservative than the existing ones, which are based on standard or other Lyapunov functionals and are more conservative. Numerical examples are given to demonstrate the effectiveness and the benefits of the proposed method. Their work also motivates others to use their construction to develop new results for other cases.

Time delay is commonly encountered in natural systems and in man-made systems such as communication networks, transportation and chemical, biological, mechanical and electronic manufacturing processes. The inclusion of time-delay dynamics is inevitable in modelling them. The presence of significant time delay is likely to pose a great difficulty for feedback control and deteriorate system performance. Thus, stability and stabilisation of delay systems is fundamentally important in both theory and applications, and is probably the hottest topic in control field. In fact, five out of the top 10 most-cited papers of Automatica in 2006–2010 are on this topic. Stability criteria for time-delay systems can be classified into two categories: delay-dependent and delay-independent criteria. Since delay-dependent criteria make use of information on the size of delays, they are less conservative than delay-independent ones in general. During the last decade, considerable attention has been devoted to the problem of delay-dependent stability analysis and controller design for delay systems. Fixed model transformations are the main methods dealing with delay-dependent stability problems. Among them, the descriptor model transformation method combined with Park's or Moon et al's inequalities is very efficient.

Prof Wang's group, in collaboration with Prof **Hang** Chang Chieh and Prof **Lee** Tong Heng, has been active in delay systems research over the last two decades. With PhD students Bi Qiang, Zou Biao, Zhang Yu, Zhang Yong, Liu Min, Ye Zhen and Nie Zhuyun, both FFT-based frequency domain and integral-based time domain methods are developed to model delay systems effectively and efficiently from relay or step tests, and relevant controller auto tuning techniques are also proposed, which form a number of patents. With the help of outstanding research fellows, Dr Zheng Feng, Dr Lin Chong, Dr He Yong and Dr Hua Changchun, significant contributions are made on stability and stabilisation of delay systems. In order to reduce conservatism, a free-weighting matrix method is proposed to study the delay-dependent stability for delay systems, in which the bounding techniques on some cross-product terms are not involved. On the other hand, although some delay-dependent stability criteria are presented for systems with multiple delays, they do not take the relationship among the delays into account. A new development is provided to reduce conservatism for multiple time-delay cases by making use of much information of the time delays. Based on respective stability analysis results, various stabilising control design methods via state feedback have been given. Besides, stabilisation of delay unstable processes is addressed in great detail with necessary and sufficient conditions. Loop gain and phase margins for multivariable feedback systems are defined and computed.

Prof Wang's research interests are mainly in modelling, estimation, prediction, control, optimisation and automation for complex systems, including but not limited to industrial and environmental processes, new energy devices, medical engineering and financial markets. He has published over 300 technical papers, of which nearly 200 are in international journals, and received over 3,000 cross citations with h-index of 30. He has authored or co-authored six books entitled Finite Spectrum Assignment for Time Delay Systems (1999), Advances in PID Control (1999), Relay Feedback: Analysis, Identification and Control (2003), Decoupling Control (2003), LMI Approach to Analysis and Control of Takagi-Sugeno Fuzzy Systems with Time Delay (2007) and PID Control for Multivariable Processes (2008), all published by Springer-Verlag. He co-holds six patents in the USA and Singapore, two of which have been licensed in the USA.

SKETCH2PHOTO: CONVERT DOODLES TO PICTURES

Many software packages, such as Adobe Photoshop and Pixel Image Editor, exist for photo editing. However, most of us have very limited skills in manipulating images using high-technology programmes. But imagine the infinite possibilities we can achieve if we could turn a simple doodle into a realistic picture.



Figure 1: A freehand sketch is converted into a photo-realistic picture by seamlessly combining multiple image components retrieved online. The input sketch plus overlaid text labels is shown in (a). Composed pictures are shown in (b) and (c). Images used in composition are shown in (d)

Take Figure 1 as an example. A matchstick figure is shown in (a). By using the Sketch2Photo system, the figure is automatically converted into the realistic pictures, as shown in (b) and (c). Sketch2Photo, a programme developed by Asst Prof **Tan** Ping and his collaborators in Tsinghua University, China, works by searching and analysing thousands of online images and combining the most suitable ones.



Figure 2: System pipeline of our preliminary work

Figure 2 shows the pipeline of the Sketch2Photo system. The input is a user-drawn sketch giving a text label for each scene item. The system first searches the Internet with the provided text labels. Among returned images, it only considers "algorithm-friendly" ones, where automatic image analyses tend to succeed. It then cuts out the main object from these images and optimises the combination of image components to generate a consistent composition.

A paper describing this method was published in the prestigious SIGGRAPH Asia 2009 conference held in Japan. The Sketch2Photo system was described as "mind blowing", "coolest" and "most innovative" by several mass media, including the UK newspaper, the Daily Telegraph as well as Spiegel and many other technique websites. The video demo at vimeo.com attracted more than one million clicks in the first six months. In addition, Sketch2Photo was recognised as one of the "10 Netexplorateurs of the Year 2010" (ten most promising digital initiatives in 2010) by Netexplorateurs. Netexplorateur is a new digital practice observatory that gives out ten awards annually. It operates under the aegis of the offices of Secretary of State for Strategic Studies, Development of the Digital Economy and the French Senate.

WALKING DOWN MEMORY LANE

It was the year 2001 when NUS ECE selected a Sri Lankan undergraduate who had been ranked 5th in the GCE A-Level examination. Nine years down the road, on 7 June 2010, this same student stood in front of the NUS community as Dr Suranga **Nanayakkara**. This narrative unfolds his story.



Looking towards the MIT from the other side of the Charles River

I was nominated for the undergraduate scholarship programme. But one of the requirements was a written English essay on any topic. My English writing skills were very basic and I could barely scribble two paragraphs about my mother. I could have poured my heart out for an essay on my mom, but that was all I could manage in an essay in English. In the end, surprisingly, I won the scholarship! It gave me the extra motivation I needed to aim higher.

The first semester at NUS gave me a rather bumpy start. It was not the cultural shock or the homesickness that was unbearable. The computers and mode of communication were. Computers and the English language were completely new to my world. Most of the terms used in lectures were beyond my vocabulary and, as a result, I had a hard time surviving my first semester. Friends had to help me install software applications. They even taught me how to use MSN messenger! I knew I had to do something before it was too late. I started sitting in the front row in lectures and made it a point never to skip any. I even carried a small cassette recorder with me to record the whole lecture. Then I would sit down with dictionaries to make sense out of the recording. It was a tiring process, but I enjoyed the challenge.



Visit to Golden Gate Bridge during Postdoctoral attachment at MIT Media Lab

The "F" I got for my computer programming practical exam was my wake-up call. I failed because I couldn't type the code in time. But I didn't give up. On the contrary, I put in a lot of effort not just to pass but to excel. Finally, all my hard work paid off when I received all A's, along with two A* distinctions by the end of the semester. I was glad that I sailed smoothly through the rest of the semesters once I got the hang of it. I also successfully completed a semester at the University of Birmingham, United Kingdom, on a student exchange programme. I managed to get involved in extracurricular activities in addition to the academic subjects I had taken. It gave me pride to represent TeamNUS cricket for eight years and to be recognised as "The Most Valuable Player" in 2007.

Graduating in 2005 with first-class honours, I decided to pursue my PhD with NUS. I was blessed with three outstanding research faculty members: Dr Elizabeth **Taylor** from TMSI, Prof Lonce **Wyse** from IDMI and Assoc Prof **Ong** Sim Heng from ECE. They supervised and guided me over the four years of my graduate studies. They were friendly, approachable and supportive all the way through. Most importantly, they believed in me, giving me extra confidence to go through very difficult situations.



Me and my PhD supervisors – Dr Elizabeth Taylor, Prof Lonce Wyse, Assoc Prof Ong Sim Heng



Visit to Hollywood during student attachment at University of Southern California



Beginning of a new journey - PhD commencement

During my four-year doctoral research, I developed a cross-modal sensory system to enhance the musical experience of the hearing-impaired. Part of this research was carried out in California and Sri Lanka. The system received exceptional feedback; many hearing-impaired users confirmed that using the system improved their ability to hear music. Our work was featured in print and electronic media, including NUS research gallery, The Straits Times newspaper in Singapore and the national television channel in Sri Lanka. We published our work in CHI'09, which was the first-ever full paper by an all-NUS team accepted for this premier conference.

Presenting my work at CHI'09 was a memorable experience. I got the chance to interact with renowned researchers in the field of Human Computer Interaction. The CHI experience helped me secure a postdoctoral attachment at MIT Media Lab, where I am currently working as Postdoctoral Associate.

Overall I had nine wonderful years at NUS. I am grateful that they gave me the opportunity to excel. Looking back, I am happy to have made the best out of what NUS has given me. I thank all my friends, colleagues and my family for being there for me all those years. Without them, I wouldn't have survived.

ALUMNI

PLEASANTLY SURPRISED

SHARING BY DR DARREL CHONG

The year 2000 was special for me. Not only was it the beginning of a new millennium but it was also the second year of my undergraduate life and I felt a desire to be actively involved in a campus society. Naturally, I looked into the Engineering Club. However, the recruitment period had finished by the time I got round to it. Seemingly unfortunate, I was left with only one choice – the Institute of Electrical and Electronics Engineers (IEEE) student branch. I went for the election and, by one vote, became Vice-President of the branch. The rest was an exciting ride.

My journey with IEEE as an active volunteer was a humbling experience. The involvement exposed me at an early age to matters that I would face in a global organisation. I learnt to work in teams, understand issues, recommend solutions, listen, speak up only when required, recover from missed goals, persist forward, and so on. Volunteering in IEEE gave me the taste of positions that I later learnt that I needed to hold with wisdom and humility. It put me in positions that I learnt not to lust after. It presented opportunities that taught me more about life and working with people, but it also contradicted my previously held beliefs (why volunteer when you can get paid for doing something else in your free time). While I did get shaken at times with an overload of responsibilities, I was fortunate to have had the entire learning experience. One thing that I am sure is that IEEE is like an open field. It allowed me to do all I wanted that was good for an institute and for humanity in general. It is borderless. It allowed my creativity to run free and wild like an unleashed horse.

The highlight of my experience began at the 1st Asia-Pacific Student Congress that took place in Singapore in 2002, which became a biennial congress for Region 10 to be later held in Hong Kong, Beijing, Madras, and, soon, Auckland. In 2004, a global student award was implemented after I put up a concept paper. In 2006, the first global online seminar was launched to serve young engineering professionals. Today, this has become a formalised service of IEEE GOLD. In 2008, a humanitarian fellowship as well as the first humanitarian workshop was implemented in Boston with a team of committed volunteers from the USA.



Dr Darrel Chong (bottom left) and Prof Lawrence Wong (top right) at the 2005 IEEE Section Congress

Certainly, I enjoyed the openness that the institute offered, which gave me space to try out my judgement and the ability to pull off a project. With this experience behind me, I am certainly more confident to do similar tasks in my workplace. I have seen that has happened in my PhD journey and now my work as Asia & Middle East Marketing Manager for a global supply chain company.

In a way, I surprised myself. A decade down the road, I was nominated in 2011 as the Chair to oversee student activities worldwide. This responsibility requires me to lead a team of nearly 30 volunteers from all over the world, supported by capable staff to govern policies, and run products and programmes to serve more than 100,000 student members globally.

Currently, I am also secretary of IEEE Region 10, supporting Prof Lawrence **Wong**, IEEE R10 Director, to lead the 87,000-member-strong Asia-Pacific. How do I cope? I let my passion, commitment and friendships take me as far as I can go.

What motivates you? Try looking out for open fields and opportunities that will give you space to try out new ideas to take you away, at least for a while, from the usual academic pursuit. You might discover a new side to yourself. More importantly, you might also find yourself pleasantly surprised to stumble upon an undiscovered corner of your life.

UNDERGRADUATE STUDENTS' ACHIEVEMENTS

SAFMC 2011 - ECE TEAM BAGS OVERALL CHAMPION AND MOST CREATIVE



(Clockwise from top): Wang Yuxiang, Li Shiyi, Lee Sing Jie, Ang Mei Ling Sharon, Tan Yi Ling and Phang Swee King (Team advisor)

An NUS ECE team consisting of students supervised by Prof Ben M **Chen** and Prof **Lee** Tong Heng won big time at the Singapore Amazing Flying Machine Competition 2011 (SAFMC) held on 18 March 2011.

They clinched the Overall Champion rank in Category D, a category for all universities, polytechnics and junior colleges in Singapore. The team also bagged the Most Creative (Gold) and Best Presentation (Silver) awards. The Championship prize comprised \$5,000 cash and five iPads, while the Creativity prize came with \$2,000 cash.

The competition involved a self-designed aircraft that had to complete a series of tasks including flying through a doorway, identifying symbols and flying over a beam. The NUS ECE team was the only team that designed the aircraft with full autopilot capabilities, which enabled it to complete the circuit and tasks autonomously.

Another innovation, the iPad controller, was also a major contribution to the team's overall achievement. The team had designed an iPad application, which had various functions such as live video display from the camera mounted on the aircraft. Also, they were able to control the aircraft's movement using the iPad, on top of the autopilot flight mode. This iPad design won them the Most Creative award in the same competition.

An impressive panel of experts from the defence industry and professors of different disciplines judged the entries in this event.



Apple iPad - Ground Control Station, Aircraft and Medals

The NUS ECE team comprised five final-year students: **Lee** Sing Jie majors in Computer Engineering while the rest, **Ang** Mei Ling Sharon, **Li** Shiyi, **Tan** Yi Ling and **Wang** Yuxiang, are Electrical Engineering students. Team advisor, **Phang** Swee King, is a PhD student from the NUS Graduate School for Integrative Sciences and Engineering.

SAFMC is organised by Defence Science Organisation National Laboratories and Science Centre Singapore. The winning project is partially supported by Prof Chen and Prof Lee's research projects funded by Temasek Defence Systems Institute and Temasek Laboratories.

Team members at the prize presentation ceremony

TERAHERTZ METAMATERIALS

Han Ningren

A Final Year Project (FYP) thesis on terahertz metamaterials by **Han** Ningren, an EE4 student, was selected to represent the Faculty of Engineering for the university-level Outstanding Undergraduate Researcher (OUR) Prize 2011. A paper entitled "Broadband Multi-layer Terahertz Metamaterials Fabrication and Characterization on Flexible Substrates" arising from his thesis and for which he is the first author, was published in Optics Express Volume 19, Issue 8, 2011 (http://www.opticsinfobase. org/oe/abstract.cfm?uri=oe-19-8-6990). Ningren's paper was also featured under research highlights in the May issue of Nature Photonics (www.nature.com/naturephotonics), a leading journal in the field of optics and photonics.

In his work, Ningren employed a multilayer metamaterial scheme to extend the operating region of terahertz metamaterials based on split-ring resonators (SRRs) from narrowband to broadband. The terahertz metamaterials were fabricated by using femtosecond laser micro-lens array lithography on 100-µmthick polyethylene naphthalate films. By stacking up differently designed, single-layer terahertz metamaterials into a multilayer configuration, the bandwidth of the resonance response increases by up to four times that of traditional single-layer metamaterials. Numerical simulations reveal that the broadband response is due to a selective excitation of SRR layers inside the multilayer metamaterials towards certain frequencies within the broadband response. This work can potentially be applied to broadband terahertz devices in, for example, biomedical imaging systems.

Ningren was supervised by Assoc Prof **Hong** Minghui from the ECE Department and Dr **Lim** Chin Seong from the Data Storage Institute (DSI, A*STAR).

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GRADUATE STUDENTS' ACHIEVEMENTS

The Liquid Interface System

LIQUID INTERFACES – A NEW CREATIVE ENTERTAINMENT TECHNOLOGY

In November 2010, a team of students and research staff from the Mixed Reality Lab led by Assoc Prof Adrian **Cheok** walked away with the Creative Showcase Golden Award at the 7th International Advances in Computers and Entertainment Conference, a premier forum for interactive entertainment, held in Taiwan. The team's winning entry was their liquid interface system.

A liquid interface is a tangible, malleable, 3-D, multi touch interface where actuation, representation and self-configuration occur through the morphing of ferromagnetic fluids, combined with Hall sensing technology. When the system is configured to act as a xylophone, for example, the liquid interface enables the user to create 3-D musical sculptures that can be morphed in real time through the user's direct interaction with the ferromagnetic fluid. Further, the mallets used to play the "instrument" are fitted with rare-earth magnets that are repelled by the electromagnets actuating the ferromagnetic fluids, thereby providing resistance and vibration similar to those experienced when playing a real xylophone.

Prof Cheok's team members include PhD students Kasun **Karunanayaka** and Jeffrey Tzu Kwan Valino **Koh**, undergraduate students **Heng** Zhi Wei Jeremy, **Liu** Yi Jiang and Eishem Bilal **Naik**, research intern Manoj **Krishnan**, and research fellows Dr Mili John **Tharakan** and Dr Jose R. **Sepulveda**.

CONFUCIUS CHAT

Wang Xuan, a second-year PhD student, received the Best Oral and Poster Presentation award for the Communication Technologies and Interface track at the Young Researchers and PhD Workshop for Research on Innovative Solutions for Elderly at the 2010 Ambient Assisted Living Forum in Denmark. She was also ranked third overall at the workshop.

Her winning entry, entitled "Confucius Chat: Mediating Cultural Communication between Elderly and Children Using New Media", showcases an online platform that enables the elderly and the young to "chat" with a virtual reconstruction of a well-known Chinese social philosopher, Confucius.

Dubbed "Confucius Chat", this platform represents a new form of cultural computing aimed at preserving Chinese cultural heritage. To give users a meaningful chat experience, Confucius Chat is driven by a complex algorithm utilising advanced natural language processing techniques to accurately interpret user queries and match them to appropriate entries in a knowledge database of Confucianism. Building this database required Wang Xuan to collaborate with Confucian scholars from the Department of Chinese Studies at NUS, thus making her research interdisciplinary in nature. As an extension of this work, Wang Xuan is now developing an application to bring Confucius Chat to users of the Apple iPhone, iPad and iTouch to enable more people to learn and understand one facet of Asian cultural heritage.

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Wang Xuan

Wang Xuan is supervised by Assoc Prof Adrian **Cheok**.

IN APPRECIATION OF PROF MS LEONG'S CONTRIBUTIONS

Prof Leong

The history of the ECE Department may be traced to 1969 when the Faculty of Engineering (comprising three departments in electrical, mechanical and civil engineering) was constituted in Prince Edward campus under the then University of Singapore. After joining the fledgling department in 1973, Dr **Leong** Mook Seng contributed to the development of the microwave-related curriculum and facilities (including the major restructuring that took place in 1977 during the relocation to its current site on the Kent Ridge campus). Active in building up research programmes in microwaves and semiconductors, he was promoted to full Professor in 1989.

Following the establishment of the Postgraduate School of Engineering in 1990, Prof Leong served as Deputy Director (until 1992) and Acting Director (until 1993). After succeeding Prof **Kooi** Pang Shyan in 1996 as Head of the Microwave & RF Group, he led a wide array of research projects with funding provided by external sponsors. One such project (which he recently handed over to two new colleagues prior to his retirement) is the multinational collaboration with researchers in Chile, the United States, Canada, Australia and Bulgaria.

A Fellow of both Electromagnetics Academy (Boston, USA) and the Institution of Engineering and Technology (London, UK), Prof Leong has also been active in the international microwave community. He served as Associate Editor of *IEEE Transactions on Antennas & Propagation* (2004–2010) and is on the editorial boards of *IET Proceedings on Microwaves*, *Antennas & Propagation* and *Microwave & Optical Technology Letters*. In addition, he chaired the organising committees for *Asia-Pacific Microwave Conference* and *Progress in Electromagnetic Research Symposium* when Singapore hosted these conferences (1999, 2003 and 2009).

His sterling contributions over a career spanning some 40 years are well appreciated by ECE staff, alumni and students, who collectively wish him a happy retirement.

ECE ALUMNI FAMILY DAY 2011

Block out the date in your calendar for the Department's alumni homecoming! Enjoy a fun-filled, yet educational, ECE alumni family day packed with activities and events for the whole family. Highlights include a magic and puppet show for the kids, a guided tour of selected ECE labs, Henna art, caricature drawing, face painting, balloon twisting, a sumptuous buffet lunch and a lucky draw. Admission is free!

Date : 6 August 2011 (Saturday)

Time : 10:30 am to 2:30 pm

Venue : Block EA, Engineering Auditorium

Snapshots from last year's ECE Alumni Family Day