Abstract Booklet

School of Electrical and Electronic Engineering

ANNUAL RESEARCH CONFERENCE 2013

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Welcome to ARC 2013!

On behalf of the School of Electrical and Electronic Engineering, the ARC 2013 Committee would like to offer a warm welcome to this year's conference proceedings. It is a great honour to welcome you to the 15th Annual Research Conference at Newcastle University.

The School of Electrical and Electronic Engineering at Newcastle University aims to provide a research environment in which ambitious new and original ideas can flourish and in which every individual member of staff can be research active. The School was awarded a 5A for research in the RAE 2001. Research has increased dramatically since the RAE 2001 and we have exceeded our targets for the RAE 2008. In The Sunday Times University Guide on Research Quality EEE is ranked amongst the top 5 schools in the UK. Our research work is centred on four major research groups of international standing in Communications, Sensors and Signal Processing, Emerging Technologies and Materials, Microelectronics System Design and Power Electronics, Drives and Machines.

The School runs an Annual Research Conference which provides a showcase for our research students and young research staff. This annual event is an excellent opportunity for staff and research students to come together with industrial partners to celebrate the school's research and collaborative links. It is a great networking event, where attendees can meet people from other research areas, exchange knowledge and discuss common research interests.

There are a few changes to this year's ARC, such as a new paper submission and review, hosted by Microsoft's Academic Conference Management Service. This was implemented for ease of submission, paper sorting, assigning reviewers and the review activity. The committee is delighted at the performance of the service and hope this service will be used as standard at future research conferences. The second change is that the abstract booklet will be provided electronically, reducing the conference's paper consumption by some 3000 pages, equivalent to an average whole tree! Therefore this year's ARC conference is more environmentally friendly. This abstract booklet will also be supplied on branded USB sticks for future reference.

Finally, this year will be the first ARC to have an awards ceremony combined networking event and group photographs at the Great North Museum. This will consist of a speech given by the Deputy President of the IET, Barry Brooks, followed by prize giving for best papers, presentations and posters. The networking event is aimed at encouraging cross-research-group networking as well as with the industrial sponsors and representatives from the IET.

The committee is very pleased to welcome this year's Industrial Sponsors, Intel and Cummins Generator Technologies and the partnership with the IET. We would like to express our thanks to the generous sponsors for making this event possible. Without them, this conference could not have gone ahead.

We would like to extend our thanks to the Postgraduate Research Coordinator, Mrs. Gill Webber, the Director of Postgraduate Studies, Prof. Volker Pickert, the Head of School, Prof. Barrie Mecrow for their invaluable

assistance, cooperation and support. Special thanks go to the Heads of Research Groups and Research Staff for their cooperation in finding academic and RA presenters offering to contribute to the proceedings.

This year, the conference will consist of around 100 technical presentations on varying areas of electrical engineering to around 150 attendees. The presentations cover all research groups and presenters range from PhD students to Research Associates and Professors.

We hope that you find the two days interesting, that it provokes your thoughts and that you thoroughly enjoy both days of the Annual Research Conference 2013.

Best Wishes,

Christopher Spargo
Committee Chair

Arslan Ahmed
Committee Vice-Chair

Richard Martin
RA Rep / Events Coordinator

Nikhil Ponon
Student Liason

Daniel Appleby
Industrial Liason

Roziah Aziz
Media / IT Executive

TIME	ARC 2013 Presentations Schedule – Day One Research Beehive 23 January 2013		
8:45 - 9:15	**Registration**		
9:15 - 9:30	**Welcome and Introduction** **Professor Volker Pickert, Postgraduate Research Director** **Room 2.21 & 2.22**		
9:30 - 10:30	**Keynote Presentation** **Intel Corp** **Room 2.21 & 2.22**		
10:30 - 10:50	**Coffee Break**		
	Presentations – Room 2.21		**Presentations – Room 2.22**
10:50 - 11:05	Ahmed Sabaawi	10:50 - 11:05	Nizar Dahir
11:05 - 11:20	Alaa Al-Rubaie	11:05 - 11:20	Graeme Coapes
11:20 - 11:35	Anvar Tukmanov	11:20 - 11:35	Dr Andrey Mokhov (staff)
11:35 - 11:50	Dr Dave Graham (staff)	11:35 - 11:50	Hock Low
11:50 - 12:05	Arslan Ahmed	11:50 - 12:05	James Docherty
12:05 - 12:20	Hong Zhang	12:05 - 12:20	Dr Arfan Ghani (staff)
12:20 - 13:30	**Lunch Break** **Poster Session – Room 2.20**		
13:30 - 13:45	Ibukun Adewale	13:30 - 13:45	Amer Kareem
13:45 - 14:00	Jeff Neasham (staff)	13:45 - 14:00	Aziz Roziah
14:00 - 14:15	Kaiwen Yu	14:00 - 14:15	Dr Dave Atkinson (staff)
14:15 - 14:30	Nick Rutter	14:15 - 14:30	Bassim Jassim
14:30 - 14:45	Phetcharat Parathai	14:30 - 14:45	Christopher Spargo
14:45 - 15:00	Dr Rajesh Tiwari (staff)	14:45 - 15:00	James Widmer (staff)
15:00 - 15:20	**Coffee Break**		
15:20 - 15:35	Qi Wang	15:20 - 15:35	Dave Winterborne
15:35 - 15:50	Riki Mukhaiyar	15:35 - 15:50	Edward Sciberras
15:50 - 16:05	Sankar Qader	15:50 - 16:05	Idris Musa
16:05 - 16:20	Dr Salama Ikki (staff)	16:05 - 16:20	Dr Richard Martin (staff)
16:20 - 16:35	Sathish Sankar Pandi	16:20 - 16:35	Charles Ukpai
16:35 - 16:50	Stuart Crichton	16:35 - 16:50	Johnson Fernandes

TIME	ARC 2013 Presentations Schedule – Day Two Research Beehive 24 January 2013		
9:00 - 10:00	**Keynote Presentation** **Cummins Generator Technologies** **Room 2.21 & 2.22**		
	Presentations – Room 2.21		**Presentations – Room 2.22**
10:00 - 10:15 10:15 - 10:30 10:30 - 10:45 10:45 - 11:00	Tong Chen Sreedevi Sreekaladevi (staff) Waleed Amer Weichen Xiang	10:00 - 10:15 10:15 - 10:30 10:30 - 10:45 10:45 - 11:00	Tahani Al-Mhana Min Zhang Zheng Tan Dr Simon Lambert (staff)
11:00 –11:20	**Coffee Break**		
11:20 - 11:35 11:35 - 11:50 11:50 - 12:05 12:05 - 12:20	Daniel Appleby Hua Khee Chan Dr Alton Horsfall (staff) Karthik Nagareddy	11:20 - 11:35 11:35 - 11:50 11:50 - 12:05 12:05 - 12:20	[no session]
12:20 - 13:30	**Lunch Break** **Poster Session – Room 2.20**		
13:30 - 13:45 13:45 - 14:00 14:00 - 14:15 14:15 - 14:30	Lucy Martin Professor Anthony O'Neill (staff) Meaad Al-hadidi Mohammed Atumi	13:30 - 13:45 13:45 - 14:00 14:00 - 14:15 14:15 - 14:30	JunWen Luo Mauricio Gomez Segura Dr Delong Shang (staff) Minerva Marin Arteaga
14:30 - 14:50	**Coffee Break**		
14:50 - 15:05 15:05 - 15:20 15:20 - 15:35	Nikhil Ponon Raied Al-Hamadany Sami Ramadan	14:50 - 15:05 15:05 - 15:20 15:20 - 15:35	Athanasios Grivas Dr Fei Xia (staff) Dr Kamyar Mehran (staff)
	Closing Plenary and Presentation Ceremony **Exhibition Hall, Great North Museum**		
16:00 - 16:20	**Reception** (sparkling wine, soft drinks)		
16:20 - 16:40	**Speech by IET Deputy President Barry Brooks**		
16:40 - 17:00	**Prize Giving** IET Deputy President (Best Paper; Presentation; Best Poster)		
17:00 - 17:10	**Conference Close** Prof Barrie Mecrow (Head of School) and Chris Spargo (ARC Committee Chairman)		
17:10 - 17:20	**School / Group Photographs**		
17:20 - 18:00	Networking Event		

ARC 2013 Poster Presentations Schedule – Day 1
Room 2.20 – Time:
23/01/2012

ETM / CSSP / MSD / PEDM (15)

1	Hengda Ding
2	Zheng Chu
3	Yuanyi Zhao
4	Kongjing Li
5	-
6	Sandip Roy
7	Neal Wood
8	-
9	Ammar Karkar
10	Musa Alyaman
11	Haider Alrudainy
12	Bharti Srivastava
13	Hubin Zhao
14	Mingzhe Hu
15	Jacob Varughese

ARC 2013 Poster Presentations Schedule – Day 2
Room 2.20 – Time:
24/01/2012

PEDM (15)

16	Ahmed Alturas
17	Nabeel Ahmed
18	Congqi Yin
19	Francis Mulolani
20	Sana Ullah
21	Xu Deng
22	Ma-Ede Besharati
23	Haimeng Wu
24	Musbahu Muhammad
25	Chen Wang
26	Mohamed Ahmeid
27	Yaman Zbede
28	Zheng Liu
29	Abdlrhman Alfrhan
30	Ahmed Althobaiti

Keynote Presenters

Intel - Day 1

Bernie Capraro - Intel Ireland Silicon and Nanotechnology EU Research Programme and Project Manager

Bernie received a Masters Degree in Engineering (MEng with distinction) from Newcastle upon Tyne Polytechnic (now The University of Northumbria at Newcastle) and has been working at Intel for the past 16 years holding various Engineering and Management roles across all four wafer fabrication facilities. Bernie is currently responsible for all silicon nanotechnology EU projects involving Intel Ireland, delivering potential solutions for materials, equipment and processing techniques required for the future technology nodes. Bernie's semiconductor career spans 26 years, with other Process and Equipment Engineering positions held at Telefunken GmbH, Nortel/Bell Northern Research, Applied Materials and Newport Wafer Fab.

Presentation Abstract: Intel - who do you think we are? As the computing industry continues to evolve, Intel Corporation endeavours to provide the hardware, software and innovation the world needs to meet the ever increasing needs and expectations of businesses and consumers. What is it that enables Intel to be ready to serve these tough markets, and what part does Intel Ireland play?

Cummins Generator Technologies - Day 2

At Cummins Generator Technologies, it's not just the products we make that set us apart – it's how we engage our customers every day. The unique combination of knowledge, dependability and innovation we bring to each relationship turns everyday service into excellent efficiency, making it possible for our customers to compete more successfully throughout the world.

Cummins Generator Technologies manufactures the world's broadest range of AC generators from 0.6 to 20,000 kVA under the STAMFORD®, AvK® and MARKON® product brands. We use our experience and knowledge gathered from a large and diverse number of applications of synchronous generator installations worldwide to provide expertise in offering integrated design solutions that help our customers compete more successfully throughout the world. Internationally renowned for built-in quality, our AC generators set the standard for ruggedness, reliability and versatility.

Cummins Generator Technologies is part of Cummins Inc,. a global power leader, incorporating complementary business units that design, manufacture, distribute and service engines and related technologies, including fuel systems, controls, air handling, filtration, emission solutions, and electrical power generation systems. Cummins, having it's headquarters in Columbus, Indiana (USA), employs approximately 44,000 people worldwide and serves customers in approximately 190 countries and territories through a network of more than 600 company-owned and independent distributor locations and approximately 6,000 dealer locations.

Institution of Engineering and Technology - Award Ceremony, Day 2

Mr Barry Brooks BSc(Eng) FCGI FIET - IET Deputy President

Barry Brooks (Electrical Engineering, Imperial College) had a successful Royal Navy career – submarine electrical and nuclear propulsion engineer, R&D projects, and Whitehall (MOD strategy, resources and planning, and Cabinet Office (working with government departments)). As Commodore, working with industry, he helped to design and improve MOD's Smart Acquisition project management. Now in his second career, he provides director-level support to make complex, high-risk, high-value engineering, procurement and change programmes successful, gaining an extensive range of contacts and invaluable insights into engineering issues faced by global industry.

As Chairman of GB&I Regional Board, Barry chaired regional consultation conferences with active member communities and helped Global Operations and Regional Boards to become more effective. He is a Professional Registration Assessor/Interviewer and IET Connect Local Representative.

Barry chaired Somerset & West Wiltshire Committee. He helped to strengthen Council's role in advising the Board of Trustees. As Trustee/Vice-President (2005-09), chaired Membership & Regions Board, sponsored LN Support Project, led new IET Governance implementation, championed embedding Young Professionals into member-staff Boards, applying the "one-team working together" approach to deliver IET's Plan. He is active in Worshipful Company of Engineers (administering Environmental Engineering Award), City & Guilds College Association (building closer alumni/student links).

Invited Staff Abstracts

ETM (Emerging Technologies and Materials)

TBC
Dr. Alton Horsfall
Room: 2.21, Day 2, Time: 11:50 - 12:05
TBC

Strained Silicon Heterojunction Bipolar Transistor
Prof. Anthony O'Neill
Room: 2.21, Day 2, Time: 13:45 - 14:00
The key idea in a Silicon Germanium (SiGe) Heterojunction Bipolar Transistor (HBT) is the incorporation of Ge in the base. This reduces the energy bandgap Eg, and increases the current gain of the transistor. However, the amount of Ge that can be incorporated in the base is limited by material constraints. Epitaxial growth of SiGe layers beyond a certain thickness can lead to strain relaxation by the generation of defects. Therefore, it is interesting to increase the Ge concentration while keeping the strain at a tolerable level. Strained Si HBTs have been demonstrated with a maximum current gain of 3700 using a relaxed $Si_{0.85}Ge_{0.15}$ virtual substrate, $Si_{0.7}Ge_{0.3}$ base and strained Si emitter. This represents 10x and 27x larger gain compared with pseudomorphic SiGe HBTs and Si control BJTs that were manufactured in parallel and had current gains of 334 and 135, respectively.

CSSP (Communications, Sensors and Signal Processing)

Inferring Real Dimensions from a 2D Image for Home Mobility Applications
Sreedevi Sreekaladevi
Room: 2.21, Day 2, Time: 10:15 - 10:30
Photogrammetry is a topic of interest to many, as it has many technical and commercial uses like surveying buildings or structures, modelling accident scenes, product inspection/measurement for quality control etc. Although many methods have been proposed to date, it still remains a big challenge to derive accurate measurements from images. In this work, a simple method to capture dimensions from photographs is being investigated. The idea is based on the computation of position of a reference object lying in space. Once the position of the reference object is known, further measurements can be carried out on the plane in which it lies. Several experiments have been performed to test the accuracy of the method and it has been found that measurements can be taken to a tolerance of within +/- 25 mm, using even ordinary digital cameras.

Large MIMO for Next Generation Wireless Systems
Dr. Salama Ikki
Room: 2.21, Day 1, Time: 16:05 - 16:20
Massive MIMO is an emerging technology that scales up MIMO by an order of magnitude compared to current state-of-the-art. We think of systems that use antenna arrays with a few tens (or even hundreds) antennas, that simultaneously serve many tens of terminals in the same time-frequency resource. The basic premise behind massive MIMO is to reap all the benefits of conventional MIMO, but in a much greater scale. Overall, massive MIMO is an enabler for the development of future broadband (fixed and mobile) networks which will be energy-efficient, secure, and robust, and will use the spectrum efficiently.

Development of low cost ultrasound scanner
Jeff Neasham
Room: 2.21, Day 1, Time: 13:45 - 14:00
This presentation will describe the development and testing of an extremely low cost ultrasound scanning device which connects via USB to any available PC or mobile device. Drawing on innovative signal processing and circuit designs from decades of sonar research in the School, the device could be manufactured for as little as £30-40 and it has the potential to have a major impact on healthcare in underdeveloped regions of the world.

GPS Software Receiver Approach for Ionospheric Scintillation Mitigation
Dr. Rajesh Tiwari
Room: 2.21, Day 1, Time: 14:45 - 15:00
GPS (Global Position System) is a satellite-based navigation system used in many applications but unfortunately its performance degrades during severe ionospheric scintillation. This scintillation corresponds to rapid fluctuations in phase and/or amplitude of the received transionospheric radio waves and can be severe at high and low latitudes leading to error in the position solution. The scintillation induced excess carrier phase jitter may lead conventional PLLs (Phase Lock Loop) to lose lock. Thus, the carrier tracking loops require a larger bandwidth to follow the fast phase changes. In a tracking loop, it is well known that the NCO (Numerically Controlled Oscillator) generates the replica of the incoming waves in the IF band and it is then compared at the discriminator. The phase error obtained from the discriminator passes through the filter to the NCO to obtain the updated replica waveforms. This loop continues until the phase error is minimized. The widening of the bandwidth of the PLL is one solution to this problem although at the cost of introducing additional noise. Another solution is a Fast Adaptive Bandwidth (FAB) approach for implementing the PLL. The adaptive nature of this approach arises from comparing phase errors with a pre-defined threshold, widening the PLL bandwidth when this threshold is reached and reducing the bandwidth when the phase error is less than the threshold. With the FAB approach, the general PLL tracking jitter is optimally reduced. However, an initial value and threshold for the PLL bandwidth is required representing the initial dynamic phase conditions. Thus our method to mitigate ionospheric scintillation involves a combined strategy of the physics-based WBMod (Wide Band Modeling) ionospheric scintillation prediction together with a fast adaptive bandwidth for the GPS tracking loop. Results of implementation of this approach will be presented.

NEWTON - Novel Sensing Network for Intelligent Monitoring of Infrastructure
Dr. Dave Graham
Room: 2.21, Day 1, Time: 11:35 - 11:50
The NEWTON project aims to provide a revolutionary solution to the structural health monitoring (SHM) of infrastructure for industrial applications. This is achieved through the development of wireless, low-cost, self-powered, autonomous electromagnetic sensors which can be interrogated from a remote reader. The system is a novel integration of radio frequency identification (RFID), pulsed eddy current (PEC) and acoustic techniques, facilitated by powerful intelligent nonlinear system identification and analysis based signal processing for fault diagnosis and condition/health monitoring. This paper presents a design methodology for the sensor hardware to simultaneously improve sensor performance and effective read-range.

MSD (Microelectronic System Design)

Self-timed SRAM Design and Testing
Dr. Delong Shang
Room: 2.22, Day 2, Time: 14:00 - 14:15
It is well known that asynchronous circuits will play an important role in the future. Research on asynchronus circuits has been re-activated for more than two decades. A number of asynchronous counterparts, such as

asynbchronus microprocessor, asynchronous DMA controller, have been proposed and designed. However, existing asynchronus SRAM in the world can only work under a strict timing assumption (bundle data). Since four years ago, our Newcastle team has been working on fully asynchronous SRAMs. After overcoming certain difficulty, we sucessfully proposed 6T, 10T, and 8T fully asynchronous SRAM, and the 6T SRAM has been taped out, fabricated, and testing. In this talk, I will present the expeience on the SI SRAM design, and testing.

A new compositional approach to system design
Dr. Andrey Mokhov
Room: 2.22, Day 1, Time: 11:20 - 11:35

One of the difficulties in designing large scale systems is the necessity to comprehend and to deal with a very large number of system configurations, operational modes, and behavioural scenarios. It is often infeasible to consider and specify each individual mode explicitly, and one needs methodologies and tools to exploit similarities between the individual modes and work with groups of modes rather than individual ones. The modes and groups of modes have to be managed in a compositional way: the specification of the system should be composed from specifications of its blocks. This includes both structural and behavioural composition. In this talk, a new compositional approach to system design is presented.

Potential applications for asynchronous data communication mechanisms (ACM's) in on-chip monitoring and control networks
Dr. Fei Xia
Room: 2.22, Day 2, Time: 15:05 - 15:20

ACM's are a class of fundamental data-transfer methods which connect differently clocked processing domains. ACM research started in the 1970s and reached a high degree of maturity by the early 2000s, with a full taxonomy and detailed algorithms published. With computation increasingly constrained by the utilization wall, dynamic and real-time control of computation is increasingly relevant for complex chips, both today and in the foreseeable future. Such on-chip sensing and control involve moving data of types different from the "regular" data of the main computation. This talk speculates about potential uses of ACM's in on-chip condition monitoring and computation control networks based on the types of sensed and control data traffic in question. The hypotheses forwarded are meant to stimulate discussions and benefit the presenter and audience alike.

Optogenetic Neural Stimulation using high brightness GaN micro LED arrays – The technology and commercialization
Dr. Kamyar Mehran
Room: 2.22, Day 2, Time: 15:20 - 15:35

In 2003, the revolutionary discovery of channelrhodopsin-2 allowed researchers to genetically re-engineer nerve cells to become light sensitive for the first time. In parallel, Dr Degenaar pioneered development of the arrays of ultra-bright micro-LEDs necessary to stimulate these cells. The advanced base technology uses very high brightness GaN micro LED arrays bonded to a CMOS controller chip. The CMOS chip can be programmed to make the LEDs provide coded pulses of light to stimulate nerve cells which have been made light sensitive by gene therapy (optogenetics), and are currently being used for in-vitro and in-vivo research. This core technology is being incorporated into a number of products for research and medical use and will ultimately be part of a retinal prosthesis headset product to return functional vision, initially to sufferers of Retinitis Pigmentosa who comprise 1:3000 of the population, which is expected to bypass the many problems which have plagued introduction of visual prostheses for the last two decades. This presentation will further describe the technology and also will discuss the attempts for commercialisation of this bespoke optoelectronic technology for neuroprosthesis market.

Multi-mode Individually Addressable Micro-LED Arrays for Optogenetic Neural Stimulation
Dr. Arfan Ghani
Room: 2.22, Day 1, Time: 12:05 - 12:20

The optoelectronic stimulation of photosensitized retinal neurons could prove to have many advantages over present electronic approaches. In this talk, we explore the architecture and results from a compact CMOS-Gallium Nitride optoelectronic stimulator which has sufficient brightness to stimulate neurons photosensitized with Channelrhodopsin. The multi-mode controller is prototyped for a 16x16 array and results are presented. It will also be discussed that how this architecture could be scaled up for better resolution requirement of the retinal prosthesis.

PEDM (Power Electronics, Drives and Machines)

Flexible DSP-based control hardware for power converter applications
Dr. Dave Atkinson
Room: 2.22, Day 1, Time: 14:00 - 14:15

This talk will give a brief overview of a DSP-based controller system developed within the PEDM group. The system comprises both hardware and software and was developed for PhD projects which require power converter control facilities. The control hardware has been designed to have the flexibility to cater for a range of power converter topologies and sensor arrangements. The controller is based on a Texas Instruments TMS320F28335 digital signal processor which is a high performance floating-point device which also incorporates IO features useful for power electronics control applications. Two systems will be described. The first is restricted to low voltage applications and the second is capable of operating with a range of converters of either commercial or in-house design.

Batteries for electric vehicles: characterisation and rapid non-destructive testing
Dr. Simon Lambert
Room: 2.22, Day 2, Time: 10:45 - 11:00

With increased penetration of electrically driven vehicles into the national fleet the scale of battery production has significantly grown in recent years. As with any production process the quality control procedures are an essential part of bringing quality products to market. Currently, state-of-the-art quality control for electric vehicles is time consuming and costly with varying degrees of accuracy. Electrochemical characterisation of the battery technology can lead to models based on empirical data. Variances in these models based on known manufacturing or fatigue modes can be used to target specific, active electrical measurements. A targeted test can then be used to reduce testing time at the quality control stage with the degree of accuracy as a function of the amount of gathered empirical data. Presented is a characterisation and data processing method leading to rapid non-destructive testing for high capacity Li-ion batteries.

Rare Earth Magnet Free Motors for the Automotive Industry
James Widmer
Room: 2.22, Day 1, Time: 14:45 - 15:00

Rare-earth permanent magnets have been widely used as they bring clear benefits to electric motors in terms of high torque density and efficiency, essential elements in the design of automotive traction motors. However rare earths have in recent years suffered from high and volatile prices. Their extraction has also been shown to have a damaging environmental footprint; a concern where they are used in green technologies. Along with other international researchers, most notably in the UK and Japan, Newcastle University has for many years researched a class of electric motor, which use no magnets, known as Switched Reluctance Machines (SRM). Newcastle University has developed and demonstrated new variants of these motors, creating new physical topologies and

also demonstrating new ways of driving and controlling these machines. The University is now applying these approaches along with other ideas (such as improvements in materials) to the development of motors for use in electric and hybrid electric vehicles ranging from passenger cars to trucks. Three ongoing projects are variously sponsored by a well known car manufacturer, a global manufacturer of engines and generators and one of the world's foremost steel producers. All have the intention of entering full scale production from 2017 onwards. The presentation will therefore describe the background to this research, some findings to date and its future direction.

Design of a six-phase switched reluctance machine for electric vehicles
Dr. Richard Martin
Room: 2.22, Day 1, Time: 14:45 - 15:00

Recent years have seen increasing development in electric vehicle technology in response to environmental concerns and rising costs. It is predicted that this development will continue for passenger cars and that growth in commercial vehicles using electric technology will increase. Most electric vehicles utilise rare earth permanent magnet materials and the demand for rare earths is similarly predicted to rise over the coming years. However, there are concerns about price volatility and security of supply of these materials. The rare earth free Switched Reluctance Machine (SRM) is therefore an attractive option and the application of SRMs to electric vehicles is a topical area of research. One disadvantage of SRMs in this application is high ripple torque but it has been shown that this can be reduced by using a high phase number, and furthermore that a six-phase SRM can be driven from a modified conventional three-phase drive. This presentation describes concept design work undertaken on a six-phase SRM for a commercial vehicle in a parallel hybrid context. The continued development of an optimisation strategy using electromagnetic finite element analysis will be discussed. Three topologies will be described and compared, and a design concept proposed for further development.

Student Abstracts

ETM (Emerging Technologies and Materials)

Deposition and Characterisation of Barium Titanate for Front and Back-End-Of-Line IC Fabrication
Daniel Appleby
Room: 2.21, Day 2, Time: 11:20 - 11:35

Thin-film MIM capacitors with barium titanate (BTO) insulating layers were fabricated using pulsed laser deposition (PLD) and sputter deposition. Due to the differing growth methods the MIM structures show different characteristics in the as-grown films. It was found that PLD MIM capacitors showed tunable capacitance and reasonable permittivity with minimum amounts of remnant polarization, while sputter deposited films had low permittivity and linear capacitance. There is large permittivity suppression, known as the 'dead-layer', apparent in films up to 360 nm in thickness, hindering the benefits of BTO thin-films. A shift in the paraelectric/ferroelectric phase transition temperature is also evident. In order to investigate these properties, electrical measurements through IV and CV, and material characterisation through Raman, AFM, and XRD are used. This work aims to investigate the possibility of including BTO into both the back-end-of-line (BEOL) and front-end-of-line (FEOL) integrated circuit (IC).

The evolution of Low Frequency Noise in thermally aged 4H-SiC lateral JFETs
Hua Khee Chan
Room: 2.21, Day 2, Time: 11:35 - 11:50

Low frequency noise is one of the critical metric in analogue circuit design as it defines the operability of the electron device. To examine the effect of high temperature stress on 4H-SiC lateral JFET two transistors sample were thermally aged at 400°C & 500°C open to air for 1000 hours. The transistors low frequency noise behaviours were then characterised and compared against a virginal sample. Excess noise is found in the sample thermally aged at 500°C and three potential sources on the device structure were examined using its I-V relation and low frequency noise measurement to investigate the dominant cause of observed excess noise.

Oxygen functionalisation of epitaxial graphene for chemical sensing applications
Karthik Nagareddy
Room: 2.21, Day 2, Time: 12:05 - 12:20

Oxygen functionalised epitaxial graphene (OFEG) chemiresistor sensors were fabricated for sensing polar organic analyte vapours in the ambient atmosphere. The electrical characteristics of the sensor showed an increase in resistance to polar protic analytes, whilst the resistance decreased upon exposure to polar aprotic vapours. The OFEG sensors showed a significant increase in response time and an order of magnitude improvement in the recovery time in comparison to non-functionalised epitaxial graphene (NFEG) sensors. A strong correlation between the dipole moment of an analyte and the magnitude of the response was observed, where OFEG sensors showed a large linear increase in the magnitude of response in comparison to a small nonlinear change in resistance for NFEG sensors.

4H-Silicon Carbide Complementary Metal-Oxide-Semiconductor Devices for High Temperature Applications
Lucy Martin
Room: 2.21, Day 2, Time: 13:30 - 13:45

This project involves the characterisation and optimisation of 4H-SiC CMOS structures designed for high temperature applications. The influence of process techniques on the characteristics of metal-oxide-semiconductor (MOS) devices has been investigated by means of electrical and physical characterisation. This project aims to highlight and explore the issues within silicon carbide MOS such as threshold voltage instability, low channel

mobility and oxide reliability, particularly the high interface trap density at the semiconductor-dielectric interface, and to improve the technology in order to further enhance the commercial potential of SiC CMOS for use in high temperature environments.

Atomistic calculations for SO2 defects in CdTe
Meaad Al-Hadidi
Room: 2.21, Day 2, Time: 14:00 - 14:15

Cadmium telluride (CdTe) is promising material for use in optoelectronics. Defects in this material reduce its capability to be use in these devices. Hence, it is important to understand the effect of impurities upon the properties of the original material. Two high frequency peaks (1097 and 1108 cm-1) have been observed experimentally, the origin of these modes is uncertain. Some experimental evidence attribute these modes to sulphur dioxide (SO2) dissolved in the crystal. This paper presents a theoretical study of the likely location of SO2 with reference to vibrational frequencies in CdTe using the atomistic AIMPRO software. Based on our calculations it is expected that more than type of SO2 defects structure present in the lattice. Therefore, we have studied vibrational modes of SO2 in different site and with different orientations for this molecule trapped at various sites. We concluded that the most likely responsible for the observed frequencies is the SO2 interstitial inside the CdTe.

Atomistic modelling of polarisation of nitrogen centres in diamond
Mohammed Atumi
Room: 2.21, Day 2, Time: 14:15 - 14:30

Diamond is an attractive material because of its extreme physical properties. The preferential alignment (polarisation) of defects in diamond enhances the contribution in quantum-based application field such as quantum information processing. Also, diamond-based magnetometers have a wide field of potential applications such as magnetic field sensing which can be used to detect very small magnetic fields. Preferential orientation of defects in synthetic diamond with respect to the growth surface is very important to understand the mechanism of the defect incorporation. It has been observed that some defects in diamond are preferentially aligned to specific orientations with respect to growth surface. Recently, experiments have shown that the nitrogen-vacancy (N-V) centre in diamond exhibits polarisation with two [111]-orientations pointed-out of growth (110)-surface and it grows in as units. In this work quantum mechanical theory has been used to investigate the preferential alignment of nitrogen-related defects on different diamond surfaces.

Effect of deposition conditions and post deposition thermal treatment on titanium nitride
Nikhil Ponon
Room: 2.21, Day 2, Time: 14:50 - 15:05

Titanium nitride (TiNx) was reactively sputtered using a titanium target in a nitrogen ambient. The deposition conditions were varied to find the lowest resistivity. TiN films with resistivity as low as 80 μΩcm were obtained when deposited at silicon process friendly conditions. A higher nitrogen partial pressure is found to decrease the resistivity of the deposited film. The films were then annealed at various temperatures to find the thermal stability and impact on resistivity. TiN films were stable against oxidation up to 500 C when annealed in an oxidising environment. Films were also annealed at high temperatures for them to be used in the front-end-of-line applications (FEOL). As deposited (AsD) films were annealed in vacuum at temperatures up to 1000 C and are found to be stable. The vacuum annealing increased the stoichiometry of the films and further reduced the resistivity of the films.

Structural and electronic properties of metal/SrTiO3 interfaces: Density functional theory
Raied Al-Hamadany
Room: 2.21, Day 2, Time: 15:05 - 15:20

The miniaturization of the integrated circuit components implies the demand for new materials. As high-k oxide, SrTiO3 has implemented as reliable dielectric in many devices. In addition to its ferroelectric behaviour, SrTiO3 exhibits interesting dielectric properties. The leakage current is the main parameter for monitoring the electrical performance of the integrated circuits. The charge transfer cross the electrode/dielectric interface might be the main source of leakage current. In the present study, electronic and structural properties of metal/SrTiO3 interfaces (metal: Pt, Au, Al, Ti and TiN) have been carried out using quantum mechanical software (AIMPRO). The agreement of the calculated metals work functions with experimental measurements proves the reliability of the adopted methodology. Results for metal/SrTiO3 interfaces show the favourability of TiO2 terminated interfaces. Furthermore, electronic structures of interfaces between SrTiO3 and multi metallic electrodes simplify the complexity of choosing the desired electrodes for different application. The presence of additional oxide interfacial layer between the SrTiO3and the highly oxidise electrodes found to be significantly affected the electronic structure of interface.

Electrical Resistivty in Silicon Nanostructures
Sami Ramadan
Room: 2.21, Day 2, Time: 15:20 - 15:35

SINWs based devices have been proposed for future applications in nanoelectronics and nanosensing. The electrical properties of these devices strongly depend on the conductivity of the NWs. Therefore, the change of conductivity with the thickness of NWs should be taken into account during the design of such devices. The electrical resistivity of highly doped SINWs and silicon thin films, measured using Van der Paw method, shows that the electrical resistivity increases with decreasing nanowire and film thickness. Surface modification of thin film, using HF cleaning, produces drop in resistivity but the increase in resistivity is still observed with decreasing film thickness. The numerical calculations of surface-depletion due to interface traps performed on Si thin films fit the resistivity obtained using Van der Paw measurements. This indicates that surface-depletion can significantly alter the carrier concentration and resistivity in silicon nanostructure.

CSSP (Communications, Sensors and Signal Processing)

A New Approach to Iris Segmentation Using Mathematical Morphology and Graph Cut
Charles Ukpai
Room: 2.22, Day 1, Time: 16:20 - 16:35

The efficacy of a human recognition system based on the iris biometrics is highly dependent on the performance of an iris segmentation algorithm. Detecting iris boundaries is a challenging step in iris recognition given the effect of noise and other artefacts including eyelid and eyelash occlusion, eye shadow, reflection and poor illumination. In this paper, we propose a novel iris segmentation algorithm based on morphological transforms and graph cut optimization algorithm. First, pre-processing is done to remove reflections from the original iris image by applying a series of morphological filters until indempotence. Then, the inner (pupil) boundary is detected and segmented by a combination of canny edge detector and morphological operators. Eyelid and eyelash occlusions are detected and removed by transforming the image using Discrete Wavelet Transform (DWT) and measuring the image texture using a statistical approach. Finally, the outer (limbic) boundary is segmented using a modified graph cut optimization algorithm. Experimental results based on CASIA and UBIRIS databases shows that our approach outperforms the traditional approach in performance and speed.

Generating Cancellable Biometric using Matrices Operations
Riki Mukhaiyar
Room: 2.21, Day 1, Time: 15:35 - 15:50

This research had the objectives to make a cancellable feature for biometric proposed based on the similarity between a non-inverted needed of biometric feature in cancellable biometric and a non-inversed matrix in matrices. A feature can be categorized as a cancellable feature when it is non-invertible to the original image. The same thing applies to matrices. The matrices cannot be inverted when satisfying three situations. Firstly,

there is one zero row at least. Next, there is a row that is a multiple of another row. And lastly, the matrix form is not a square. In this research, fingerprints will be the first biometric technology to be used in generating a cancellable biometric. The reason is because fingerprints one of the most reliable and promising personal identification technology.

Deposition and Characterisation of Barium Titanate for Front and Back-End-Of-Line IC Fabrication
Hong Zhang
Room: 2.21, Day 1, Time: 12:05 - 12:20

Non-destructive testing (NDT) and evaluation of defects in metals is an important practical issue in several critical environments including steel bridges, railroad tracks, railroad car wheels and power plants etc. Although there are several standard non-destructive testing techniques, near-field microwave techniques have shown tremendous potential for significantly adding to the available non-destructive testing for this purpose. An open-end waveguide operating in the X-band (8.2GHz to 12.4GHz) for detecting the permittivity variance in one layer of multilayered dielectric structures is presented. Using an efficient analytical model NMF for extracting defects characteristic which covered with multilayered dielectric structures, the effects of varying liftoff distance and electrical parameters of the waveguide on its performance are analysed.

Comparison of Iterative Decoding Schemes applied to Physical Layer Network Coding
Alaa Al-Rubaie
Room: 2.21, Day 1, Time: 11:05 - 11:20

Physical layer network coding (PNC) is a novel technique that allows two users to exchange messages in a wireless network. PNC takes place at a relay node and exploits the interference caused by incoming signals from the two users to increase throughput. This interference is mapped to a binary vector that represents the exclusive-OR (XOR) of both users' messages and is broadcast from the relay node back to both users. After both users have recovered the binary vector, message exchange is completed when each user applies an XOR to their original binary message and the binary vector to obtain the other user's message. In this paper, the performance of low-density parity-check codes and turbo codes is evaluated in a two-way relay network with PNC. Results obtain from combining PNC and different iterative decoding algorithms at the relay will be presented along with results for PNC without decoding at the relay.

Asynchronous Uplink IDMA Detection for Shallow-Water Acoustic Channels
Sankar Qader
Room: 2.21, Day 1, Time: 15:50 - 16:05

In this paper, a novel adaptive detector for uplink interleaved division multiple access (IDMA) transmissions is proposed. In conventional IDMA detection, a turbo-type manner of exchanging log-likelihood ratio (LLR) between elementary signal estimation (ESE) and a posteriori probability decoder (APP-DEC) efficiently removes the multi-access interference (MAI) and inter symbol interference (ISI) effects of the received signal. While, in the proposed IDMA receiver, a chip-level centralized decision feedback equalizer (CDFE) has been utilized to jointly remove MAI and ISI impairments. The decoder outputs and the estimated channel response are used by the CDFE to competently detect the transmitted symbols. Experimental shallow water impulse response channels have been used in the simulation. Simulation results illustrate the amount of interferences suppressions in the CDFE when compared to decentralized DFE (DDFE) and linear equalizer (LE) performances.

Nano-antennas for Solar Energy Collection
Ahmed Sabaawi
Room: 2.21, Day 1, Time: 10:50 - 11:05

In this paper, a study is conducted into spiral nanoantennas for solar energy collection, with the aim of increasing

the captured electric field utilizing Finite Element Method (FEM) based simulations. The obtained results demonstrate that the electric field in the gap can be increased by coupling more elements using feeding lines. Two types of spiral nano-antennas have been used for this purpose, i.e. square and logarithmic spiral nano-antennas, which resonate near the wavelength of 13 um, where the main of energy is expected to be located. Furthermore, the polarization responses of the designed nanoantennas to 2 orthogonal polarized waves have been obtained and presented.

Achievable Secrecy Rate of Bit-Interleaved Coded Modulation
Weichen Xiang
Room: 2.21, Day 2, Time: 10:45 - 11:00

We study the impact of various modulation mapping strategies and signal constellation shapes on the secrecy rates achievable with bit-interleaved coded modulation (BICM) schemes. Transmission over an Ergodic Rayleigh fading channel is assumed throughout this work.We determine several mapping techniques that outperform Gray and quasi-Gray labelings under secrecy constraints. Distance spectrum is the key parameter to design a mapping scheme with high achievable secrecy rate.

Single-Channel Audio Source Separation using Complex Matrix Factorization
Phetcharat Parathai
Room: 2.21, Day 1, Time: 14:30 - 14:45

In recent years, there is a growing interest in the field of single-channel audio source separation (SCASS). SCASS concerns the separation of signals that have been mixed using a single microphone. A novel approach has been developed to extract better quality of audio separated signals. This approach will exploit the complex matrix factorization (CMF) which offers the advantages of the non-negative matrix factorization (NMF) and sparse representations including sparse coding (SC) framework simultaneously. CMF is based on a mixing model defined in the complex-spectrum domain and estimates recurring patterns in the observed magnitude spectra, their activations and their phases. We derive an efficient iterative algorithm, which reduces to the multiplicative update algorithm for non-negative matrix factorization under a particular condition, and demonstrate that it yields superior performance compared with existing SCASS method. The performance of the developed algorithms will be measured using real-time audio signals in terms of the signal-to-distortion ratio.

Cooperative diversity gains: a network topology-based perspective
Anvar Tukmanov
Room: 2.21, Day 1, Time: 11:20 - 11:35

Wireless communication systems are facing a significant increase in demand for higher data rates, reliability and security. Delivery of services meeting these requirements becomes an increasingly challenging task as more devices try access the limited channel resources. In such conditions, node cooperation has emerged as a promising technology to enable diversity gains in communication between terminals with a single antenna. Specifically, in past decade it has been demonstrated that the decay rate in communication outage probability can be made arbitrarily high given sufficient number of cooperating nodes at the cost of reduced spectral efficiency and/or coordination. In this work we highlight the role of channel state information (CSI) available at relays on outage performance of cooperative communication scenarios. Analytical and simulation results demonstrate that similar diversity order can be achieved for the cases with full and only statistical CSI at relays, although for the price of higher power consumption.

Antenna-based Sensing: Smart Localization in Wireless Sensor Network
Waleed Amer
Room: 2.21, Day 2, Time: 10:30 - 10:45

In recent years, large and pervasive Wireless Sensor Networks (WSNs) have become increasingly important in several fields such as structural health monitoring, underwater monitoring, intelligent infrastructure, and

smarter cities. New innovations foretell the possibilities of merging WSNs with the fields of active-RFID and smart phones imposing new difficulties in terms of node mobility, high node density, distributed infrastructure and severe low power (with temporary power failure due to power scavenging techniques). Human detection and Tracking WSNs usually use cameras, accelerometers, temperature sensors, etc. However, some sensors may not be able to function well under emergency conditions (e.g. in power outage case cameras need light source to work properly). In the other hand, using RF-antenna only, Wireless Sensor Network (WSN) is able to collect wide range of useful information about surrounding environment based on received signal attenuation. Given values of the attenuation from several nodes, each node in network is able, with some error margin, to inspect: distances between nodes, current spectrum utilization, and humans and objects existence in the vicinity. This information is critical in case of emergency and also in cognitive radio applications e.g. spectrum sensing and intelligent localisation. The aim of this project is to design and develop a WSN that able to detect and track human in neighbourhood based on the variance in the received signal strength measured by network nodes. The WSN will be able to operate unattended under conditions of random deployment and/or mobile nodes. This WSN would represent a group of sensor nodes attached to pedestrian/car (wearable sensor, smart phones, navigation gadgets, health care, etc.) that are able to communicate with each other and form temporary clusters and to report events in the area of concern as requested by a base station. While many previous work try to reduce the effect of human and other objects in the region of a network, in this work we propose to measure this effects and use it to detect the object location. In Newcastle University laboratory, several indoor experiments have been done and they show that human existence around network region causes higher variation in the received signal strength. By analysing this variation, it is possible to determine human location in vicinity. Future experiment will involve outdoor experiment with larger network region. Using RF-antenna sensing technique would be useful in many applications. In emergency cases, it helps first responder to detect human in accident area since they are already exist in many devices and need only to communicate with each other to perform detection process. It also offers smaller and cheaper security detection system in supermarkets and libraries. Camera usually can detect human face and shape details, but it is somewhat expensive and hence can't be deployed everywhere. On the other hand, RF-antenna based WSNs are cheap and easy to install, make it possible to deploy it densely.

On the Reduction of Simulation Times in Communications and Signal Processing
Nick Rutter
Room: 2.21, Day 1, Time: 14:15 - 14:30

Research in communications and signal processing can be extremely challenging, especially when there is a strong reliance upon the completion of time-consuming simulations that require myriad complex computations or high throughput. Consequently, this can severely impede further simulations and analysis due to time constrictions and available resources. This paper highlights the expected gains in obtaining substantial performance increases at significantly low prices through the use of general purpose graphic processing unit (GPGPU) computing. Comparisons are made between relevant serialized and parallel implementations. While this technology is not particularly new, it is relevant to note that this area of computing that maintains a very tight niche, having seen little to no exploration by a majority of researchers. As such, GPGPU computing is an emerging technology that is becoming exceptionally popular, where we should soon see it being incorporated in many computing devices – from servers and workstations to desktops and mobile devices.

Decoupling the influence of permeability and conductivity in pulsed eddy current measurements
Ibukun Adewale
Room: 2.21, Day 1, Time: 13:30 - 13:45

Eddy current (EC) sensors are widely used in the industry for non-destructive evaluation (NDE) and structural health monitoring (SHM). It has this wide acceptance mainly because it has high tolerance to harsh environments, low cost and high bandwidth. Its variant pulsed eddy current (PEC) provides even more depth information of test materials, which can be applied in lift-off measurement (displacement and coating thickness

measurement), defect measurement and material characterization. However, PEC sensors are prone to measurement errors due to a phenomenon called electrical run-out (ERO), which is attributed to the inhomogeneity of the test material. The main thrust of this paper is to investigate therefore the contributions of the electromagnetic properties (permeability and conductivity) of the sample to ERO with a view to separate the influence of these two properties. Both time domain and frequency domain analyses are carried out in this investigation viz-a-viz: transient response, differential normalized response, magnitude spectrum and normalized magnitude spectrum. This paper reveals that conductivity effects are prominent in the rising edge of the transient response; hence, changing the spectral pattern in the frequency domain whilst permeability effects dominate in the stable phase of the transient response thus this effect can be suppressed or reduced by normalization showing that it is only an amplitude change.

Preserving scene texture perception in image enhancement:
Luminance based monotonic normalisation
Stuart Crichton
Room: 2.21, Day 1, Time: 16:35 - 16:50

Mal exposed images and those taken under strong colour casts result in a reduction of visible information in an image. A great number of histogram equalisation approaches to combat this by enhancing contrast have been proposed using both local and global areas of an image. However most of these methods ignore the contents of an image whilst utilising specific scene characteristic assumptions to help alter the characteristic shape of an image histogram. This paper proposes a new method of enhancement for under and over exposed images, which preserves both the shape and monotonicity of the histogram and its components across the channel(s) using its luminance skewness, in turn preserving the perception of texture for the viewer.

Single Channel Speech Separation using Exemplar guided Utterance Model
Qi Wang
Room: 2.21, Day 1, Time: 15:20 - 15:35

We present a new approach to Single Channel Speech Separation with the aid of an exemplar source. Our method deviates from the traditional model-based method, which relies highly on speaker dependent training data. We re-address the problem by offering utterance dependent patterns extracted from the exemplar source. The resultant probability model does not require speaker dependent information, while providing on-par separation results. A Factorial Hidden Markov Model is built based on Gaussian mixture model (GMM) features from speaker independent (SI) models and an estimated utterance dependent (UD) model. This paper offers two of the methods used to extract and estimate the patterns from the exemplar source. With very specific transitional patterns, the proposed method tackles the problem of ambiguity with efficiency and accuracy. The proposed algorithm is tested using the Mocha-TIMIT database and the speech separation challenge provided by Cooke et al. To demonstrate the feasibility of the method, very recent model approach results were compared and analyzed.

Quantitative falls risk assesment using single wrist worn accelerometer-Newcastle85+ study
Sathish Sankar Pandi
Room: 2.21, Day 1, Time: 16:20 - 16:35

In many developed countries, population of oldest old (above 85 years) is growing by significant amount. Very little is known about the health status of this population. Falls are the major problem of this cohort, cost to treat elderly falls are enormous. Now, indispensable need for fall prediction systems has increased. Predicting falls in earlier would ease the burden of healthcare systems, increase life expectancy by providing earlier interventions. We aim to assess prior falls risk of this population from representative group of 299 subjects utilising signals of wrist worn accelerometer from Timed up and go test (TUG-T). We derived a novel parameter of Number of frequency band changes (NOS) and sub measures of it for retrospective falls risk assessment. This study

shows the ability of NOS to classify fallers from non-fallers, retrospectively. Cross validated logistic regression of extracted NOS measure from the signals of single accelerometer could predict falls with the mean sensitivity of 70.22%, specificity of 86.65% and accuracy of 79.59%. Results suggest that this method offers improvement to the standard falls risk measures of manually timed TUG and Berg Balance Scale (BBS). These methods offer mean sensitivities of 26.92%, 57.8%, mean specificities of 87.49%, 64.2% and mean accuracies 61.63%, 61.4%, respectively. We anticipate developed method has potential for patient management benefits in home or rehabilitation centres and permits long term continuous monitoring.

Single Channel Source Separation using Nonnegative Matrix Factorization 2D with the Flaxiable β
Kaiwen Yu
Room: 2.21, Day 1, Time: 14:00 - 14:15

Not available at time of print.

Physical-layer network coding (PNC) NDC Scheme
Tong Chen
Room: 2.21, Day 2, Time: 10:00 - 10:15

Physical-layer network coding (PNC) has the potential to significantly improve the throughput of wireless networks where the channels could be modeled as additive white Gaussian noise (AWGN) channel. As extending to multiple channels, this technique requires both amplitude and phase compensation at each transmitter and will lead to inefficient systems yielding no diversity even with perfect channel state information (CSI). In order to avoid these limitations, we apply network coding with diversity (NCD) to achieve a form of selection diversity and extend NCD to cooperative multiple access channels in this paper. However, in practical wireless communication systems, the CSI could become outdated due to the difference between the CSI used in the relay selection and data transmission phases. Hence, the selected relay may not be the best one during data transmission phase due to the dynamic change in the wireless channels. Therefore, we first explore the relation between the present and past CSIs. Exploiting this relationship, the NCD scheme with outdated CSI is investigated based on the past CSI. To evaluate the performance of this scheme, one information-theoretic metric, the outage capacity is studied under this condition.

Performance of Software Based Acquisition Techniques in a GPS Receiver under Weak and Strong Ionospheric Scintillation Conditions
Arslan Ahmed
Room: 2.21, Day 1, Time: 11:50 - 12:05

Ionospheric scintillation is the rapid random fluctuations in amplitude and/or phase of the received transionospheric radio waves resulting from propagating through electron density irregularities such as those embedded in plasma bubbles. In this study, the FFT based circular correlation method, "delay and multiply", and an innovative technique, a modified form of the delay and multiply, for GPS signal acquisition are presented. It has been found that the new innovative method involves fewer computations as noise increases and is approximately 7 times faster than the FFT based circular correlation method. It is as useful as other methods in acquiring the signal in strong to moderate amounts of scintillation.

MSD (Microelectronic System Design)

Persistency in Mixed Synchronous-Asynchronous Architectures
Johnson Fernandes
Room: 2.22, Day 1, Time: 16:35 - 16:50

With chip sizes scaling to deep sub-micron level, semiconductors are experiencing severe variability making it extremely complicated to design chips in the traditional synchronous fashion. Modern trends in digital design

are in the realm of SoCs with most benefits coming from mixed synchronous-asynchronous designs. However there is a lack of formal methods that model and verify such systems. In this paper, we propose a model to represent mixed synchronous-asynchronous behaviour and identify a new class of persistency that ensures stable circuit behaviour. Guaranteeing persistency is one of the key requirements for modelling asynchronous circuits. For synchronous designs, persistency satisfaction is self-evident as every tick of the clock triggers a sequence of persistent transitions. However persistency is not so trivial in mixed synchronous-asynchronous designs due to the existent element of asynchrony. Here, we introduce a step based form of persistency for accurate modelling of such systems.

Simulation and Validation of a Heuristic Scheduling Algorithm for Multicore Systems
James Docherty
Room: 2.22, Day 1, Time: 11:50 - 12:05

The number of embedded systems used worldwide is increasing rapidly. With each generation of equipment, consumers are expecting more computational power and functionality, meaning current designs can be considered unsuitable. As transistor feature size reaches its atomic limit, manufacturers have moved from single to multi-core environments to bridge the performance gap and continue to meet Moore's Law. However, this means job scheduling has become exponentially more complex and is reaching a point where standard algorithms are failing to cope. This paper summarizes the initial work performed creating a heuristic based algorithm that is aware of both requests and available resources and therefore is capable of managing the uncertainty brought about by these factors. The work uses Monte Carlo Simulation combined with multi-vary analysis to identify primary contributors and their contribution to scheduling.

Towards Reliable Hybrid Bio-Silicon Integration Using Novel Adaptive Control System
Junwen Luo
Room: 2.22, Day 2, Time: 13:30 - 13:45

Hybrid bio-silicon networks are difficult to implement in practice due to variations of biological neuron bursting frequency. This causes the hybrid network to have inaccuracies and unreliability. The network may produce irregular bursts or incorrect spiking phase relationships if the electrical neuron bursting frequency is not suitable for biological neurons. To solve this potentially vital problem, a novel adaptive control system based on dynamic clamp is proposed. Biological measurement is combined with an adaptive controller to control to silicon neuron bursting periods in real time. We use a hybrid pyloric network which contains three real neurons and one electronic neuron as a case study. Simulation results indicate that the silicon neuron can follow the biological neuron bursting frequency in real time to achieve hybrid network functionalities. System settling time can be achieved in 303 milliseconds and percentage overshoot kept to 1%. We believe that our methodology is scalable to various larger bio-silicon hybrid neural networks.

Reconfigurable Asynchronous Fabric (RAF) and CAD flow
Hock Low
Room: 2.22, Day 1, Time: 11:35 - 11:50

As the semiconductor industry evolves and accounts for the prohibitive cost of custom chip design and fabrication, there is ever increasing use of prefabricated and reconfigurable chips such as FPGA. Asynchronous FPGAs (AFPGA) are recognized for its high throughput performance and tolerant to delay variations caused by process variations in modern VLSI technology nodes. However, the adoption of the platform is still low mainly due to a lack of CAD tools. We propose a new RAF that wraps asynchronous logic around the conventional FPGA's soft logic elements. This has provided an opportunity for swift integration with existing FPGA CAD flows, particularly the implementation (logic Mapping) Tools. VTR CAD flow permits the expression of the newly proposed RAF architecture together with the capabilities of synthesis, packing, P&R and timing analysis. The infrastructure is also used for the impartial comparative evaluation of different architectures base on a set of benchmark circuits.

A High-Rate Telemetry Modulator Using Low-Power Digital Techniques for Biomedical Implants
Minerva Marin Arteaga
Room: 2.22, Day 1, Time: 14:15 - 14:30

The rapid advances in microelectronics have led to the design of small and low-power-consuming biomedical devices that can be implanted inside the body and get data in real-time. The design of a biomedical implant must take into account constraints such as low size, low power consumption, and high data rate. The most promising approach to design these devices is the UWB technology because of its simplicity, and high data rate capability. The modulation scheme is another major subject since its purpose is to help the transmitter not only to achieve a high data rate, but also to provide a stable performance in the human body channel. The main goal of this project is to develop a biomedical telemetry modulator capable of modulating the data at rates larger than 10 Mbps with a minimum of external components, and using low-power digital techniques.

Deadlock-Free Adaptive Routing for 3D NoCs
Nizar Dahir
Room: 2.22, Day 1, Time: 10:50 - 11:05

This paper proposes a new method for designing adaptive routing algorithms for 3D networks-on-chip (NoCs). This method is based on extending the existing 2D turn model adaptive routing to 3D. A 3-D plane-balanced approach with maximal degree of adaptiveness is achieved by applying different rules for different strata of the 3D NoC. Experimental results show that the new 3D odd-even can achieve up to 23.8\% improvement in throughput over conventional 3D odd-even . The improvement is consistent for different traffic types.

A Spiking Neural Network-on-Chip Platform for Hybrid Bio-Electronic Networks
Graeme Coapes
Room: 2.22, Day 1, Time: 11:05 - 11:20

Next-generation brain-machine interfaces will consist of hybrid bio-silicon networks, where neurons will be directly connected to electronics, allowing for the functionality and behaviour of brain networks to be studied and even repaired. The development of this technology will rely heavily upon the electronic design, in particular the design of the spiking neural network architecture. This paper explores the design of such an architecture, illustrating the design and providing conceptual analysis of the network-on-chip platform, including optimization techniques to reduce the power consumption.

Accelerating shortest path computation through Multicore Architectures
Athanasios Grivas
Room: 2.22, Day 1, Time: 14:50 - 15:05

Complex Network is the new dominant way of modeling and analyzing large data sets in many scientific and engineering disciplines. Their excessive size sets an important barrier on their analysis. Single core processors are not able to analyze them on satisfactory time frames. Employing many core graphic processors as GPUs provides sufficient processing power for the analysis of such networks. However, common algorithmic techniques are not able to exploit these massive resources. In this paper, we present an accelerated version of the shortest path computation based on matrix multiplication. Dividing matrices on smaller parts and calculating them on a 336 core GPU card accomplishes a remarkable speed up.

Spike Sorting DSP device for an Implantable Biotelemetry System
Mauricio Gomez Segura
Room: 2.22, Day 1, Time: 13:45 - 14:00

Implantable biotelemetry systems for neural recording are an essential tool in studies of the function of the nervous system. Neuroscience research demands a large number of simultaneous channels, so there is a contin-

uously need to increase the capacity of these systems. Implantable circuits must be small and operate at low power levels. Communication bandwidth and power limitations require us to perform data reduction on-chip before transmission, and spike sorting is one way of accomplishing this. The aim of this work is the development, simulation and implementation of an ultra-low-power digital signal processing device (DSP) capable of processing data from action potentials in neurons using a multichannel spike sorting algorithm. It is intended that the proposed device is integrated to an implantable biotelemetry system currently under development at the School of EECE in the Newcastle University.

PEDM (Power Electronics, Drives and Machines)

Load Variations Impact on the Operating PF of a FCSC converter applied to wave energy Bouys
Tahani Al-Mhana
Room: 2.22, Day 2, Time: 10:00 - 10:15

This paper investigate the effect of load variation on the power factor of the FCSC converter applied to wave energy conversion systems.

Marine economy and flexibility with auxiliary drives
Edward Sciberras
Room: 2.22, Day 1, Time: 15:35 - 15:50

Electric propulsion in ships brings about a potential for improved efficiency, with associated fuel savings. This suitability is dependent on vessel type and operational conditions, requiring careful consideration if any benefits are to be gained. Hybridisation by combining mechanical and electrical concepts helps to exploit the advantages of both types of propulsion such that overall propulsive efficiency is improved. Auxiliary electric drives take advantage of the flexibility of electric systems to provide propulsive power at low vessel speeds via alternate prime power sources, when main engine operation is otherwise suboptimal. This work analyses the possibility of efficiency improvement by the provision of an auxiliary bidirectional drive to two case ships and their corresponding operational profile. A model was built to assess fuel consumption, such that different propulsion options can be compared by simulation, with results presented for a RoRo ship and tug vessel.

Performance Evaluation of Rotor Position Estimation in DFIG Based Wind Turbine with Different MRAS Schemes
Amer Kareem
Room: 2.22, Day 1, Time: 13:30 - 13:45

The objective of this study is to investigate the comparative performance analysis of doubly fed induction generator(DFIG) based wind turbine with two types of PI vector control using PWM modulator, one of them is indirect sensor vector control and the other is two schemes Model Reference Adaptive System (MRAS) estimators to validate the ability of detect the rotor position when connect the generator to the grid with different operation conditions. The active and reactive powers are regulated with a reasonable dynamic response with variable wind profile in sensored case. The position sensorless estimators of DFIG based on QRMRAS method is implemented and compared with RCMRAS which proved it's more robust and accurate. During the two sets of tests in adjusting the error between the reference and adaptive models, the estimated rotor position can be obtained to verify the decoupling of power.

Capacitors for High Temperature DC Link Applications in SRM Drives: Current Technology and Limitations
Dave Winterborne
Room: 2.22, Day 1, Time: 15:20 - 15:35

Recent years have seen an increase in research into switched reluctance machines for automotive traction applications, driven by the cost and scarcity of permanent magnet materials. Such machines increase the demands

on the DC link capacitor, which must maintain high reliability and long life while storing large amounts of charge at high voltages. The aim of this paper is to provide an overview of this field at the present time, which is currently lacking in the literature, identify limitations of current technology and provide impetus for future research. Current dielectric materials and their suitability for this application are assessed and compared, and then the direction of current research into novel materials is investigated.

New Control Method for Parallel Connected Three-Phase PWM Converters
Bassim Jassim
Room: 2.22, Day 1, Time: 14:15 - 14:30

Parallel converters can increase power levels, system reliability and efficiency, as well as improve the flexibility of a system. However, circulating currents are generated and this leads to current distortion, an unbalanced operation and a decline in overall system performance. In order to prevent circulating currents, one can use separately isolated dc sources or isolated ac sides via a transformer but this will lead to an increased size and cost of the system. Also, an inter-module reactor can be used in order to provide high impedance in the circulating current paths, but unfortunately the reactor cannot prevent low frequency circulating currents and it will also contribute considerable size and cost to the system. This work will present a simple control method for equally rated three-phase parallel connected PWM converters. The proposed method divides the switching cycles evenly between the equally rated converters. Accordingly, the intermodule reactors become redundant, leading to smaller size and less cost for the system.

Integration of Induction Generator Based Distributed Generation
and Shunt Compensation Capacitors in Power Distribution Networks
Idris Musa
Room: 2.22, Day 1, Time: 15:50 - 16:05

An algorithm for computing the reactive power requirement of induction generator based distributed generation is proposed in this paper. The machine equivalent circuit is combined with an AC power flow algorithm and particle swarm optimization (PSO), for simultaneous integration of induction generation and shunt compensation capacitors in a power distribution network with the objective of minimizing network power loss. The algorithm iteratively calculates the required slip for the output power of the generator to be within a small tolerance band of the specified output power. PSO is then employed to obtain the global optimal solution with the compensation capacitors locally providing the reactive power requirement of the generator. The algorithm is tested on a standard 33-bus distribution network, showing its effectiveness for the integration of induction machine based generation.

Application of Fractional Slot Concentrated Windings to Synchronous Reluctance Machines
Christopher Spargo
Room: 2.22, Day 1, Time: 14:30 - 14:45

The desire for high torque density electrical machines for traction applications, due to the advancement in electric vehicles, is increasing annually. It is advantageous to design such a motor with little or no rare earth permanent magnet (PM) material due to the environmental, political and economic challenges associated with obtaining the material for use in electrical machines. Therefore, a novel synchronous reluctance machine (RSM), with fractional slot concentrated windings (the cRSM), is explored. The impact of applying fractional slot concentrated windings to RSMs is presented and the outline of the design options for such a machine is detailed. Scaling of the fractional slot wound synchronous reluctance motor is also discussed, in order to realise a torque dense synchronous reluctance machine for traction applications.

A near state three-dimensional SVM for three-phase four-leg VSIs
Min Zhang
Room: 2.22, Day 2, Time: 10:15 - 10:30

This paper introduces a modified 3-D SVM which is called a near state 3-D SVM for three-phase four-leg voltage source inverters. The impact of 3-D SVM scheme on grounding and common-mode noise issues has never been fully investigated before. This paper firstly investigates the common-mode noises issues for a three-phase four-leg VSI, thus presenting a near state 3-D SVM which suppresses the common mode voltage (CMV) of a four-leg inverter. The steps that are needed to synthesize the reference switching vector in α-β-γ coordinate are presented in details. Calculations of the duty ratios are given and simulation and experimental results show that the switching scheme works under both balanced and unbalanced load condition. Finally, analysis based on the waveform quality is done.

Thermal Simulation Analysis of Interior Permanent Magnet Synchronous Motor (IPMSM)
Aziz Roziah
Room: 2.22, Day 1, Time: 13:45 - 14:00

The machine under study is an interior permanent magnet synchronous motor (IPM) which is generating maximum power and torque, 80kW and 280Nm respectively. This motor can achieved the maximum speed of 10,390rpm. The rotor has eight sets of three permanent magnet arranged in an inverted triangle shape. Sintered Neodymium magnet has been choosing as a permanent magnet material. Meanwhile, the stator has six coils for each pole. This motor adopts distributed type for winding. Temperature rising is a major factor threatening the magnetism of magnet, life and stabilization of a machine. Therefore, thermal analysis will be done on the machine by using Infolytica Thermnet software. The result of the simulation will be analysed and presented.

Site-Specific Doubly Fed Induction Generator(DFIG)-Based Wind Power System
Zheng Tan
Room: 2.22, Day 2, Time: 10:30 - 10:45

This paper evaluates various wind power estimation models to represent the wind energy for machine design and control purposes. Traditionally, linear, quadratic and cubic formulas have been used for interpolating wind power curves but have their limitations. Due to the fluctuating nature of wind power, they may not be accurate to model the actual wind speed profile and nor convenient for wind turbine generator design and control which demands a representative site-specific wind speed profile. On the basis of the DFIG equivalent circuit, loss components and maximum efficiency of DFIGs are derived and these are taken into account when optimising DFIGs to match the specific site of development.

Generating Cancellable Biometric using Matrices Operations

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Abstract

A cancellable biometric system aims to revote a biometric feature of an authorized person when his biometric information is misused by improper. In this system, an established biometric image is transformed to a different feature to distinguish it from the original one. Moreover, this revocable system can regenerate a new transformed cancellable biometric feature if the previous transformed feature is known by someone.

These basic concepts are similar with the idea of inverse matrix and elementary row operation in matrices domain. Biometric image as a digital image definitely can be processed in matrices domain. It means that the image is able to be imposed by matrices operations such as inverse matrix operation, elementary row operation, and Kronecker product operation. In matrix, these operations are used for several objectives whether inverting matrix elements, changing rows or columns, or enlarging size of the matrix. On the other hand, the combination of these operations even can produce a non-inversed matrix.

This research had the objectives to make a cancellable feature for biometric proposed based on the similarity between a non-inverted needed of biometric feature in cancellable biometric and a non-inversed matrix in matrices. A feature can be categorized as a cancellable feature when it is non-invertible to the original image. The same thing applies to matrices. The matrices cannot be inverted when satisfying three situations. Firstly, there is one zero row at least. Next, there is a row that is a multiple of another row. And lastly, the matrix form is not a square.

Related to the first requirement, it can be achieved by using Elementary Row Operation (ERO) where a selected row is multiplied by zero. Meanwhile, for the next requirement, since in image system it is rare for finding a row which is a multiple of another row, hence by using ERO it can be created.

Furthermore, to ensure the obtained cancellable matrix is completely masked and to be able to meet the last requirement for non-invertible matrix, in this research each elements of the transformed matrix is multiplied by an arbitrary matrix/element. This process is called Kronecker Product or Tensor Product operation. By using this process, the outcome is both matrix whose have more numerous elements and an adjustable matrix form (whether rectangle or square matrix).

In this research, fingerprints will be the first biometric technology to be used in generating a cancellable biometric. The reason is because fingerprints one of the most reliable and promising personal identification technology.

Keywords: Cancellable Biometric, Matrices, Elementary Row Operation, Kronecker Product, Tensor Product.

1. Introduction

The recent advances of information technologies and the increasing requirements for security proposed have led to a rapid development of automatic personal identification systems based on biometrics. Biometrics refers to accurately identifying an individual based on his or her distinctive physiological (e.g., fingerprints, face, retina, iris) or behavioral (e.g., gait, signature) characteristics. It is inherently more reliable and more capable in distinguishing between an authorized person and a fraudulent impostor than traditional token-based or knowledge-based methods. Among all biometrics, fingerprint recognition is one of the most reliable and promising personal identification technologies.

Biometrics authentication is highly reliable, because physical human characteristics are much more difficult to forge the security codes, passwords, hardware keys sensors, fast processing equipment and substantial memory capacity, so the system are costly. Biometric-based authentication applications include workstation and network access, single sign-on, application log on, data protection, remote access to resources, transaction security, and Web security. The promises of e-commerce and e-government can be achieved through the utilization of strong personal authentication procedures.

Secure electronic banking, investing and other financial transactions, retail sales, law enforcement, and health and social services are already benefiting from these technologies. Biometric technologies are expected to play a key role in personal authentication for large-scale enterprise network authentication environments, Point-of-Sale and the protection of applications. Utilized alone or integrated with other

technologies such as smart cards, encryption keys and digital signatures, biometrics are used in various schools such as in lunch programs and school library. Examples of other current applications include verification of annual pass holders in an amusement park, speaker verification for television home shopping, internet banking, and user's authentication in a variety of social services.

Biometric person recognition refers to the use of physiological or behavioral characteristics of people in an automated way to identify them or verify who they claim to be [1]. Biometric recognition systems are typically able to provide improved comfort and security to their users, when compared to traditional authentication methods, typically based on something that you have (e.g., a token) or something that you know (e.g., password).

Unfortunately, biometric-based people authentication poses new challenges related to personal data protection, not existing in traditional authentication methods. In fact, if biometric data are stolen by an attacker, this can lead to identify theft. More over, user's biometric cannot be changed, and they may reveal sensitive information about personality and health, which can be processed and distributed without the user's authorization [2]. An unauthorized tracking of the enrolled subjects can also be done when a cross-matching among different biometric databases is performed, since personal biometric traits are permanently associated with the users. This would lead to user's privacy loss.

Because of these security and privacy issues, there are currently many research efforts toward protecting biometric systems against possible attacks which can be perpetrated at their vulnerable points [3]. In essence, the adopted security measures should be able to enhance biometric systems' resilience against attacks while allowing the matching to be performed efficiently, thus guaranteeing acceptable recognition performance.

Based on the reason that biometric data do not vary much over time (permanence) and are very rarely shred by two people (uniqueness), privacy violations can occur if biometric are misused or stolen. Traditional methods for identifying people, for example, ID and Personal Identification Numbers (PINs), can be cancelled and reissued if the above privacy issues are compromised. But this is not possible with biometric data. Furthermore, there are privacy concerns about sharing biometric data with commercial companies and law enforcement or government agencies. To enhance security and privacy in biometrics, cancellable biometric has been introduced recently [4, 5].

Cancellable biometrics uses transformed or intentionally distorted biometric data instead of the original biometric data for identifying person. When a set of biometric data is found to be compromised, they can be discarded, and a new set of biometric data can be regenerated. Several keys issues in generating cancellable biometrics can be defined as changeability (how dissimilar the transformed data are compared to the original data), non-invertibility (transformed biometric data should not be easily converted back to the original biometric data even if the transformation method is known and the transformed data are given), reproducibility (we should be able to generate many different cancellable templates from the original data), performance degradation (the performance when using transformed templates should not be degraded much).

2. Related Work

Recently, several approaches have been proposed regarding to the cancellable biometrics. One of the first formal works in cancellable biometric was reported in [6]. In this work, the authors proposed three transforms: Cartesian, polar, and functional transformation to be used in fingerprint images. The first two methods have the drawback of the boundary problem, i.e. if an original minutiae point crosses a boundary of sectors dividing the feature space due to minor deviation of image alignment or distortion of a fingerprint, then the transformed version of the minutiae point is located far from the appropriate position. The third method deals with this issue by using local smoothing functions to distort the feature space. In [7], a locally smooth function was proposed for a cancellable fingerprint template which preserves the original geometric relationships (translation and rotation) between the enrolled and query templates after they are transformed. Therefore, the transformed templates can be used to identify a person without requiring alignment of the input fingerprint images. However, the security analysis of the above methods seems insufficient. For example, an attacker might be able to narrow down the candidates of original minutia patterns based on the constraints of continuity of minutiae orientation and local smoothness of the transform function.

As a consequence of the work reported in [6], several other investigations have been carried out. For instance, in [8], the authors presented a technique for converting a fingerprint into a binary-string template based on minutiae triplets. This binary representation is transformed into an anonymous representation using a unique personal key. According to the authors, the proposed transform in not only computationally infeasible to invert, but in the case that the biometric representation is compromised it can be redefined by simply assigning a different key. One advantage of this representation is that the existing methods that

can be found in the literature (such as bio-hashing) can be applied to this representation.

In [9], a secure method for cancellable fingerprint templates was proposed. Their method extracts a local image (patch) around each minutia, and transforms it by a projection matrix which does not change the dot product measure of two patches. The main drawback of this method is its poor accuracy in the transformed space. In the same year, the authors of [10] have presented the idea of cancellable biometrics and secure sketches to guard the privacy of biometric templates while maintaining the ability to match the protected data against a reference. The standard beyond cancellable biometrics was to carry out an irreversible transformation over images and to create matching over transformed images. They showed that applying secure sketch error correction to cancellable biometrics permits maintenance of a good matching performance.

In [11], a geometric transformation of minutiae positions is proposed to generate cancellable fingerprint templates. This geometric transformation is used for alignment. A parameter-controlled minutiae encryption is performed within a local area to generate a cancellable minutiae template, and then all local encryption results are superimposed to form a protected template. Parameters to control the minutiae encryption are generated independently of the geometric-aligned minutiae, which ensure solid non-invertibility compared to those cancellable template generating algorithms with to-be-encrypted minutiae information as parameters.

3. Proposed Method

In this research, matrices are scope of work where the established biometric feature has to be extracted to matrices domain. When the image is being processed in matrices domain, then there should be no noise at all because the existence of noise may add specific information to the biometric feature. Related to cancellable biometric, since the end of this system is verification, even a very little noise will affect the quality of cancellable feature significantly and will certainly resulting low precision in verification later on.

Thus, the early process to be done toward the result of established biometric is pre-processing. The result image of pre-processing will provide a feature with the precise value of biometric information so that when it is extracted to domain matrices, there will be no unnecessary values that go into it. Then, the result feature of pre-processing will be transformed into matrix. This matrix then will be the input of cancellable system that is going to be built. To simplify the next appellation, then it is better to name it as matrix R.

Since it is already in matrices domain, then the next thing to be discussed is how to build the system of cancellable biometrics using matrix R as an input. Firstly, matrix R will be inversed as the first step to disguise the real feature. This idea is tentatively, because it will be considered whether directly inversing matrix R is an effective way or, on the other hand, inversing matrix R after another matrix operation. The next step will be applying the Elementary Row Operation (ERO) to matrix R to obtain zero-value row or to apply Kronecker Product (KP) operation. In this research, it will be analyzed of how much zero rows needed to achieve the requirement of maximum non-invertible. Besides the use of ERO to obtain zero rows, another thing to be considered in this research is the use of ERO to create rows that are the multiple of the other rows.

In case of the ERO as the step taken, matrix R that has been imposed ERO operation; we name it as matrix K; that will go through KP operation to produce KP matrix which every initial element is unrecognizable. Let us name it as matrix M. In this KP operation, matrix K will be multiplied by tensor factor that can be in a form of matrix or integer with constant value. Let name it as S. The form and the value of factor S will be one of the analysis materials in this research. For example, if factor S is matrix S, then the value can be taken from the numbers given by a person who have registered his biometrics when he registered himself as an authentic person of a biometric whose the cancellable feature is being built. In this research, the steps of using ERO and KP will be analyzed as well, whether the use of ERO in the beginning and KP afterwards is better, or vice versa. The result of the process above will be a cancellable matrix of matrix R, and be namely as matrix H. In order to obtain a cancellable feature, then matrix H will be conversed again into the domain image.

5. Conclusion and Future Work

In conclusion, it is found that this novel approach can be relied in generating a cancellable template. Actually, there are three ways that is able to be used to produce it. Firstly, it is by inversing-enlarging-rotating the image matrix. Next is by enlarging-inversing-rotating. And the last is by inversing-charging the matrix form. However, based on the yields of all procedures, the first way is preferred to be used as the algorithm to acquire the cancellable biometric template.

Furthermore, pre-processing stage played an impontant role, especially if I go to verification step as be illustrated as follow.

1	1	0	0	0	1
0	0	1	1	1	0
1	1	1	1	1	1
1	1	0	0	0	0
0	0	1	1	0	1
0	0	1	0	1	1

(a)

1	1	0	0	0	1
0	0	1	1	1	0
1	1	1	1	1	1
1	1	0	1	0	0
0	0	1	1	0	1
0	0	1	0	1	1

(b)

Figure 3.7. (a) The pre-processing matrix which should; (b) Deviation value of the pre-processing matrix (red square)

At the moment, there is an element of matrix of the original image as a result of pre processing step that does not have value as what it is, the image will be rejected in verification process. Because, in this procedure, each of the element values describe what the image is, no matter what.

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