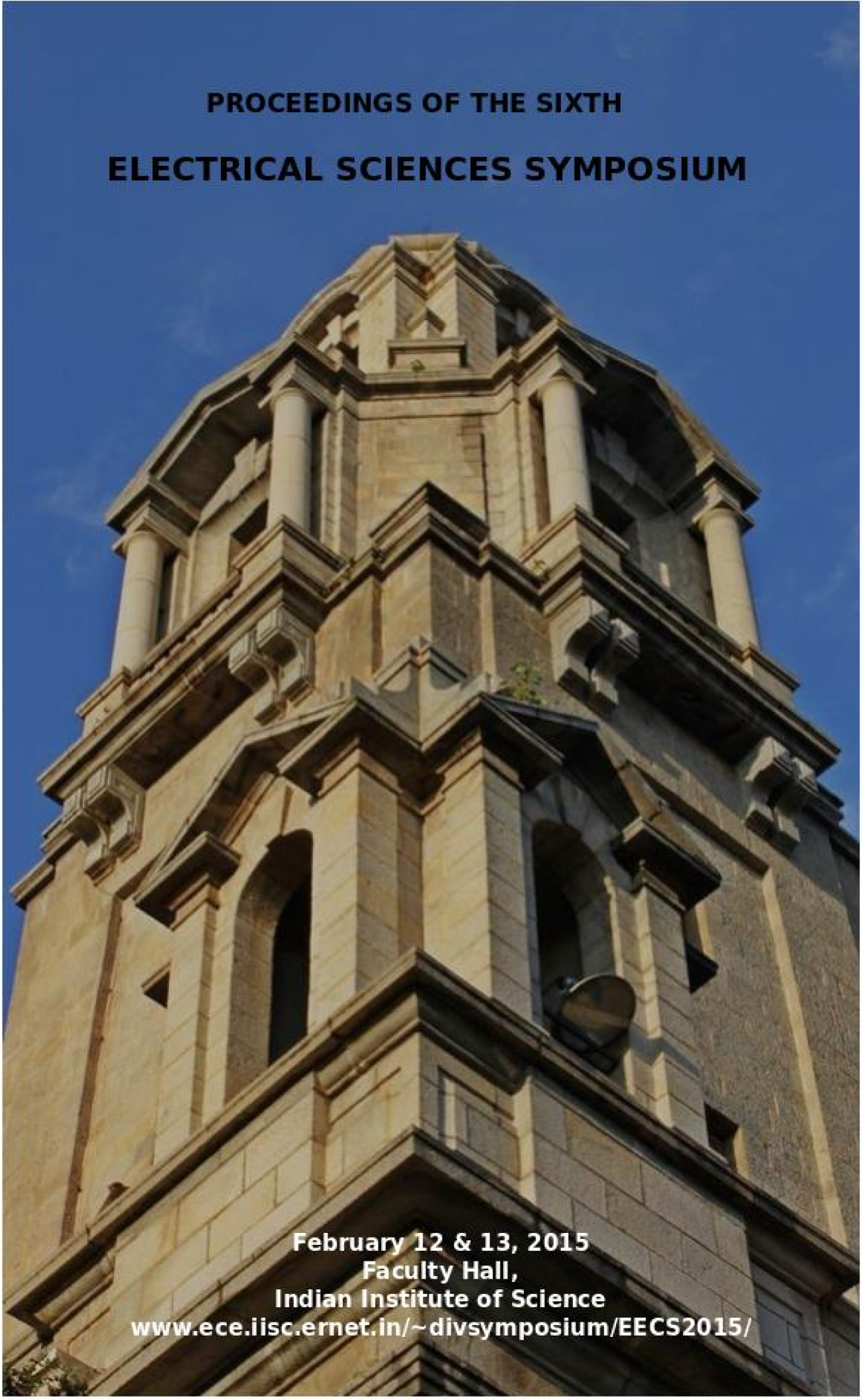
PROCEEDINGS OF THE SIXTH

ELECTRICAL SCIENCES SYMPOSIUM



February 12 & 13, 2015
Faculty Hall,
Indian Institute of Science
www.ece.iisc.ernet.in/~divsymposium/EECS2015/

Proceedings of the Sixth

Electrical Sciences Symposium

Indian Institute of Science
Bangalore, India

February 12 & 13, 2015

Foreword

The EECS Research Students Symposium - 2015 is the sixth in the series of annual events initiated by Professor Anurag Kumar in 2010. The symposium is organized by the research students of five departments:

- Computer Science and Automation (CSA)
- Electrical Communication Engineering (ECE)
- Electrical Engineering (EE)
- Electronic Systems Engineering (ESE)
- Supercomputer Education and Research Centre (SERC)

Two faculty members from each of the five departments are advising the student volunteers in organizing this event.

As per standard practice, this year's symposium features two keynote talks; five talks by young faculty members from the five departments; and 20 minute talks by research students. We have 30 talks by Ph.D. students and 2 M.Sc. poster presentation this time, organized into five sessions:

- Electronics
- Algorithms and Applications
- Networks and Games
- Machine Learning and Computer Vision
- Communications

In addition to the above, the organizers have planned three other events as well. The first is a poster session which will have showcase the work of all the student speakers. The second is a set of four invited talks on four inter-disciplinary topics being pursued actively in the Institute:

- Brain Research
- Bioengineering
- Cyberphysical Systems
- Sustainable Transportation and Urban Planning

Problems of relevance to the society and industry invariably have an inter-disciplinary flavor and the above four talks would provide the right impetus for inter-disciplinary problem solving. The third event is an Alumni Event with the objective of updating our alumni about the activities of the five departments and elicit their advice and suggestions.

The organizing committee has assembled a splendid technical program for this event and the team must be congratulated for the excellent job. We hope sincerely that the symposium will facilitate lively interactions among the participants and inspire everybody to attempt and solve intellectually challenging research problems in EECS and beyond.

Y. Narahari

Chair, Electrical Sciences Division

Organizing Committee & Schedule

Committee

Faculty Coordinators

Y. Narahari	Chair, Division of Electrical Sciences
Jayant Haritsa	Chair, CSA
Chandan Saha	CSA
Komondoor V. Raghavan	CSA
K. V. S. Hari	Chair, ECE
Dipanjan Gope	ECE
Gaurab Banerjee	ECE
P. S. Sastry	Chair, EE
Muthuvel Arigovindan	EE
Soma Biswas	EE
Joy Kuri	Chair, ESE
Shayan Garani Srinivasa	ESE
Mayank Shrivastava	ESE
R. Govindarajan	Chair, SERC
Yogesh Simmhan	SERC
R. Venkatesh Babu	SERC
Phaneendra K. Yalavarthy	SERC

Student Organizers

Prayag Gowgi, Tara Vishin	ESE
Ranjani H G, Srikant, Jobin Francis	ECE
Satyanath Bhat, Kartik Nagar, Vineet Nair	CSA
Sivaram Mudunuri, Sanjay Viswanath	EE
Mopuri Reddy, Srinivas, Ravikiran	SERC
Nilkanth Pathak (Cover photo credit)	

Schedule	
Time	**February 12, 2015 (Thursday)**
08.30 - 08.55	**Registration**
08.55 - 09.00	**Inauguration**
09.00 - 10.40	**Electronics** **Session Chairs: G. Narayanan (IISc), C. P. Ravikumar (TI), Padma Desiraju (CAIR)** **Viveka K.R** - Design of Wide Voltage Range Static Random Access Memories (SRAMs) (Ph.D., ECE) **Arjun Shetty** - Device Applications of III-Nitride Semiconductors (Ph.D., ECE) **R. Sudharshan Kaarthik** - A Voltage Space Vector Structure formed by Nineteen Concentric Dodecagons for Medium Voltage Induction Motor Drive (Ph.D., ESE) **Mohammad Hassan Hedayati** - Integrated CM filter for Single-Phase and Three-Phase PWM Rectifiers (Ph.D, EE) **Abhijit K** - Control and Design of Power Converters for Renewable Energy Systems (Ph.D, EE)
10.40 - 11.00	**Coffee Break**
11.00 - 12.55	**Session Chair: K. V. S. Hari (ECE, IISc)**
11.00 - 11.45	**Keynote Talk** Challenges and Execution of the Mars Orbiter Mission Project **Speaker: Subbiah Arunan** **Project Director, Mars Orbiter Mission, ISRO**
11.45 - 12.05	**Interdisciplinary Centre Talk (Brain Research)** Large Scale Neural Models of Brain Function **Speaker: Sridharan Devarajan**
12.05 - 12.25	**Interdisciplinary Centre Talk (Bioengineering)** Bioengineering in IISc **Speaker: S. P. Arun, IISc**
12.25 - 12.55	**Faculty Talk (SERC)** Role of Computation in a Fundamental understanding of Optical Processes **Speaker: Murugesan Venkatapathi**
12.55 - 14.00	**Lunch (Venue: Main Guest House Lawns, IISc)**
14.00 - 15.40	**Algorithms & Applications** **Session Chairs: Arnab Bhattacharyya (IISc), Rajeev Shorey (TCS Innovation Labs)** **Prateek Jha** - Towards Smart Bandages (M.Sc., ECE) **Shalini Kaleeswaran** - Program Repair by Automated Generation of Hints (Ph.D., CSA) **Abhay Sharma** - Finding a Subset of Non-defective items from a Large Population: Fundamental Limits and Efficient Algorithms (Ph.D., ECE) **Maria Francis** - Grobner Basis Algorithms for Polynomial Ideal Theory Over Noetherian Rings (Ph.D., CSA) **Farhad Merchant** - Algorithm-Architecture Co-design for NLA (Ph.D., SERC)

15.40 - 16.00	**Coffee Break**
16.00 - 17.40	**Session Chair: Jayant Haritsa, CSA/SERC, IISc**
16.00 - 16.20	**Interdisciplinary Centre Talk (RBCCPS)** Research to Application: Translating Technology for Impact **Speaker: Jay Warrior, RBCCPS**
16.20 - 16.40	**Interdisciplinary Centre Talk (CiSTUP)** Problems Related to Intelligent Urban Planning - Smart Cities **Speaker: J. M. Chandra Kishen, CiSTUP**
16.40 - 17.10	**Faculty Talk (DESE)** Proportionally Fair Spatial Aloha for Poisson Networks **Speaker: Chandramani Singh**
17.10 - 17.40	**Faculty Talk (ECE)** Sequential Decision Making in Complex Environments **Speaker: Aditya Gopalan**
17.40 - 18.00	**High Tea**
18.00 - 20.20	**Networks and Games** **Session Chairs: Chandramani Singh (IISc), Vinayaka Pandit (IBM Research)** **Kundan Kandhway** - Campaigning in Heterogeneous Social Networks: Optimal Control of Sl Information epidemics (Ph.D., ESE) **Arun Rajkumar** - Ranking from Pairwise Preferences: The Role of the Pairwise Preference Matrix (Ph.D., CSA) **Shweta Jain** - Multi-armed Bandit Mechanisms (Ph.D., CSA) **Chandrashekar L** - Approximate Dynamic Programming (Ph.D., CSA) **Swapnil Dhamal** - Models and Methods for Formation and Analysis of Social Networks (Ph.D., CSA) **Satyanath Bhat** - Mechanism Design with Interdependent Values (Ph.D., CSA) **Pankaj Dayama** - Truthful Crowdsourcing Mechanisms with Application to Geo-Sensing (Ph.D., CSA)

Time	**February 13, 2015 (Friday)**
08.30 - 09.00	**Registration**
09.00 - 10.40	**Machine Learning and Vision** **Session Chairs: Partha Pratim Talukdar (IISc), T. Ravindra Babu (Flipkart)** **Avishek Chatterjee** - High Quality Photometric Reconstruction using a Structured-light Stereo Depth Camera (Ph.D., EE) **Sanath Narayan** - Action Recognition in Videos using Trajectory Descriptors (Ph.D., EE) **Harish Guruprasad Ramaswamy** - Consistent Algorithms for Multiclass Learning Problems under General Loss Matrices (Ph.D., CSA) **Prabuchandran K.J** - Algorithms for Reinforcement Learning (Ph.D.,CSA) **Ibrahim A** - Discovering Compressing Serial Episodes from Event Sequences (Ph.D.,EE)

10.40 - 11.00	**Coffee Break**
11.00 - 12.45	**Session Chair: P. S. Sastry, EE, IISc**
11.00 - 11.45	**Keynote Talk** Opportunities to Make an Impact in Telecommunications **Speaker: Kumar N. Sivarajan** **Chief Technology Officer, Tejas Networks & Adjunct Faculty Member, ECE, IISc**
11.45 - 12.15	**Faculty Talk (EE)** Localization of Point Clouds from Incomplete Distances: Review and Recent Progress **Speaker: Kunal Chaudhury**
12.15 - 12.45	**Faculty Talk (CSA)** Updatability of Error Correcting Codes **Speaker: Bhavana Kanukurthi**
12.45 - 14.00	**Lunch (Venue: Main Guest House Lawns, IISc)**
14:00 - 16:40	**Communications** **Session Chairs: Himanshu Tyagi (IISc), Aditya Karnik (GE Research)** **Arkaprovo Das** - Fast Solvers for Electromagnetic Applications (Ph.D., ECE) **Venugopalakrishna Y. R** - Physical Layer Data Fusion Algorithms for Cognitive Radio applications (Ph.D., ECE) **Siddhartha Sarma** - Optimal Power Allocation for Protective Jamming in wireless Networks: A flow based model (Ph.D., ESE) **Vikas Kumar Dewangan** - Role of Power-Control in Enhancing the Performance of Opportunistic Selection Schemes (Ph.D., ECE) **Parthajit Mohapatra** - Fundamental Limits of Communication in Interference Limited Environments (Ph.D., ECE) **Arpan Chattopadhyay** - Impromptu Deployment of wireless Sensor Networks (Ph.D., ECE) **Shilpa Rao** - Trade-offs and Performance Analysis of Energy Harvesting Wireless Sensor Networks (Ph.D., ECE) **Sanjeev G** - Spectrum Sensing Techniques for Cognitive Radio Applications (Ph.D., ECE)
16.40 - 18.15	**Poster Session (Venue : Reception Hall)**
18.15 - 19.30	**Valedictory and Alumni Meet** **Session Chairs: R. Govindarajan (SERC), Joy Kuri (DESE)**

Contents

Session 1

Contributed Session : Electronics

Session Chair: G. Narayanan (IISc), C. P. Ravikumar (TI), Padma Desiraju (CAIR)

1.1 Design of Wide Voltage Range Static Random Access Memories (SRAMs)

Speaker: Viveka K R

Contact: krviveka@ece.iisc.ernet.in

Abstract: Applications today place a wide range of performance demands on underlying systems. These can vary from running high-definition videos to monitoring slow varying biomedical signals. The capability to operate over a wide range of supply voltages from nominal down to sub-threshold voltages enables in extending the battery life of such systems.

Researchers have demonstrated logic circuits capable of operating down to sub-threshold voltages, where as, doing so with memory circuits, specifically Static Random Access Memories (SRAMs) has proven to be more challenging. SRAMs are affected severely by the random variation caused during fabrication at advance technology nodes. This is further exacerbated at lower voltages, limiting their minimum operating voltage. External support such as reference voltage generator, timing generator or other assist circuitry are often used in literature to extend the voltage range of SRAMs. This is however undesirable as it increases the demands on the system employing the memory, increasing its power and cost.

We propose the design of SRAMs that perform well across a wide range of voltages. We have designed and fabricated a 4 kb SRAM array in UMC 130nm technology that functions from 1.2 V down to 310 mV with reads functioning down to 190 mV. The key contributions of this work are the (i) Design of Logic-Memory interface (ii) Read-path circuitry design that maximizes performance at high-voltage and extends operation down to sub-threshold voltages and (iii) Speed-up of post fabrication tuning that is necessary at ultra low voltages. Combing these techniques allows design of memories for completely integrated efficient wide voltage range systems.

1.2 Device Applications of III-Nitride Semiconductors

Speaker: Arjun Shetty

Contact: arjun@ece.iisc.ernet.in

Abstract: Continuous scaling of Si transistors has enabled us to sustain Moore's law for over 30 years. However, the physical gate length has already reached 30nm in the current 65nm technology node and is expected to reach 10nm within the next few years. This is widely believed to be the physical limit, beyond which, we have to look at alternatives to scaling in order to continue enjoying the benefits of Moore's law. III-nitrides offer unique advantages over other materials for high frequency and high power applications. In this work, we study the device applications of III-nitride semiconductors grown using molecular beam epitaxy.

The first part of our work focuses on gallium nitride based metal-semiconductor and metal-insulator-semiconductor Schottky diodes using hafnium dioxide (HfO_2) (5nm) as the insulator layer. The introduction of HfO_2 results in an improvement in barrier height (0.62eV to 0.74eV), ideality factor (6 to 4.1) and rectification ratio (5.1 to 8.9) as compared to a conventional metal-semiconductor Schottky diode.

The second part of the work deals with metal-semiconductor-metal photodetectors. Indium nitride quantum dot based IR photodetectors were fabricated. We found that increasing the indium flux density during growth resulted in an increase in quantum dot density and reduction in dark current density by 1.5 times. Gallium nitride based UV photodetectors were also fabricated. Al nanostructures were fabricated using nanosphere lithography and we observed a plasmonic enhancement of the photocurrent with negligible increase in dark current.

1.3 A Voltage Space Vector Structure formed by Nineteen Concentric Dodecagons for Medium Voltage Induction Motor Drive

Speaker: R. Sudharshan Kaarthik

Contact: sudharshan@cedt.iisc.ernet.in

Abstract: A multilevel dodecagonal voltage space vector structure with nineteen concentric dodecagons is proposed for the first time. This space vector structure is achieved by cascading two sets of asymmetric three level inverters with isolated H-Bridges on either side of an open-end winding induction motor. The dodecagonal structure is made possible by proper selection of DC link voltages and switching states of the inverters. The proposed scheme retains all the advantages of multilevel topologies as well the advantages of dodecagonal voltage space vector structure. In addition to that, a generic and simple method for calculation of PWM timings using only sampled reference values (v_α and v_β) is proposed. This enables the scheme to be used for any closed loop application like vector control. Also, a new switching technique is proposed, which ensures minimum switching while eliminating the fifth and seventh order harmonics and suppressing the eleventh and thirteenth harmonics, eliminating the need for bulky filters. The motor phase voltage is a 24 stepped waveform for the entire modulation range thereby, reducing

the number of switchings of the individual inverter modules. Experimental results for steady state operation, transient operation including start-up have been presented and the results of Fast Fourier Transform (FFT) analysis is also presented for validating the proposed concept.

1.4 Integrated CM filter for Single-Phase and Three-Phase PWM Rectifiers

Speaker: Mohammad Hassan Hedayati

Contact: mh49929@gmail.com

Abstract: Grid-connected power converters are being used increasingly in applications like, PWM-rectifiers, active-filters and renewables. Limiting the electromagnetic emission from the power converters is a challenge. The reason for generation of electromagnetic noises is the switching actions of the power converter switches. Fast turning on and off generates high dv/dt voltage transients. Voltage change with high rate of dv/dt excites the parasitic capacitances. This injects a narrow peaky current to the ground at each instant of switching. The spectrum of these peaky current spans from low frequencies to very high frequencies and causes EMI/EMC concerns. Standard approach is to add EMI-filter in addition to ripple-filter. This requires costly EMI-filters.

In this work, LCL ripple-filter is integrated with CM-filter. These are designed and fabricated to reduce the EMI/EMC noise level for single-phase and three-phase grid connected power converters. The designed filters provide paths inside the power converters by which, the parasitic capacitances are not excited. A novel LCL-filter topology for a single-phase PWM-rectifier that makes use of bipolar PWM method is proposed. The proposed topology eliminates high dv/dt from the dc-bus CM voltage by making it sinusoidal (50 Hz). Hence, the high frequency common-mode current injection to the ground is minimized, and the EMI/EMC noise level is reduced. A new method is proposed, for two parallel-connected H-bridge power converters, to make the CM voltage sinusoidal and free of high frequency pulses. The proposed method uses unipolar PWM with carrier interleaving that reduces the ground leakage current by more than an order of magnitude. These solutions provides high performance filtering, while mitigating EMI/EMC concerns and results in lower overall power conversion system cost.

1.5 Control and Design of Power Converters for Renewable Energy Systems

Speaker: Abhijit K.

Contact: abhiekulkarni@gmail.com

Abstract: In distributed generation systems, power converters form the interface between the electric source and the grid. The motivation for this work is to design and control power converters for renewable energy systems to ensure very good power quality, efficiency and reliability. In this work, two power converter topologies are developed. For low power rating of less than

1kW, line-frequency transformer based topology is developed. This topology injects low-order harmonics to the grid, which is undesirable. A novel control method using adaptive harmonic compensation technique and a proportional-resonant-integral (PRI) controller is proposed and validated. For power rating of a few kilowatts to 10kW, a compact high-frequency transformer ac-link inverter topology is developed. A lossless snubber and a modulation scheme is proposed which eliminates overvoltage spikes due to transformer leakage inductance. Thermal modelling and analysis of paralleled surface-mount MOSFETs used in the inverter is performed.

Phase-locked loops (PLLs) are used for grid synchronization of power converters and closed-loop control reference generation. Analysis and design of synchronous reference frame PLL (SRF-PLL) and second-order generalized integrator (SOGI) based single-phase PLL considering unit vector distortion under the possible grid conditions of harmonics, unbalance and dc offsets is proposed and validated. Both SRF-PLL and SOGI-PLL are low-complexity PLLs. The proposed designs ensure very good performance during grid voltage abnormalities.

The proposed design and control aspects are useful in implementing improved power quality, efficient and reliable power converters for renewable energy applications such as photovoltaic systems.

Session 2

Keynote Talk : Mars Orbiter Mission

Session Chair: K. V. S. Hari, ECE, IISc

Mars Orbiter Mission

Speaker: Subbiah Arunan

Abstract: Mars Orbiter Mission (MOM) is India's first interplanetary mission conceived and executed to demonstrate ISROs technical capabilities and also to perform science experiments around Mars with indigenously developed scientific instruments. Mars Orbiter Mission spacecraft was built at ISRO Satellite Centre - Bangalore with payloads contributed by Space Application Centre - Ahmedabad, Space Physics Laboratory of Vikram Sarabhai Space Centre Thiruvananthapuram and Laboratory for Electro Optics Sensor - Bangalore. The MOM spacecraft was launched from Satish Dhawan Space Centre - Shriharikota on November 5th 2013 by Polar Satellite Launch Vehicle XL, India's workhorse launch vehicle.

The execution of MOM project involved various disciplines such as satellite making, payloads realization, launch vehicle adoptability, mission design and development and providing navigational solutions all of which were executed within a very short period of time, less than two years . This was a major challenge for ISRO. The findings of a study committee were used as the basic guidelines for the mission design and the vast experience of ISRO was used to adopt and modify various heritage systems for the Mars mission.

The challenging areas of the mission were launch vehicle mission design, spacecraft system design such as the propulsion system (restart of liquid engine after nearly 300 days of hibernation), power system (solar panel to cater for requirements of both earth and Martian phases), deep-space communication system (very long distance and varied on-board gain requirements), incorporation of a host of on-board autonomy features (very long time of travel for signals), thermal control systems (optimization of hardware for varied environments between earth and Martian phases) and the design, development

and qualification of deep-space mission specific hardware like delta differential one way ranging instrument, most of which were executed for the first time. Providing navigational solutions with utmost precision for critical events such as earth bound maneuvers, trans-Mars injection, trajectory correction maneuvers and Mars orbit injection were other areas of major challenge successfully overcome by ISRO. The presentation will provide more details regarding the above aspects of Indian Mars Orbiter Mission.

The presentation provides more details regarding the above aspects of Indian Mars Orbiter Mission.

Brief Biography: Shri Subbiah Arunan joined Vikram Sarabhai Space Centre (VSSC) of Indian Space Research Organisation (ISRO) in the year 1985 after completing graduation in Engineering from Madras University. Before joining ISRO Satellite Centre (ISAC), Bangalore in 1998, he worked as Project Engineer and Project Manager in the areas of Cryogenic Propulsion for GSLV and Control System for PSLV in Vikram Sarabhai Space Centre. He held the positions of Deputy Project Director for Technology Experiment Satellite (TES), Cartosat-1, Chandrayaan-1 and Associate Project Director for Chandrayaan-2 before taking up the current responsibility of Project Director, Mars Orbiter Mission. As the project director of the Mars Orbiter Mission, he inspired his team members to achieve all objectives of this mission. In recognition, he has just been honoured with the Padmashri, the fourth highest civilian award of the country by the Government of India.

Session 3

Interdisciplinary Centre Talk : Brain Research

Session Chair: K. V. S. Hari, ECE, IISc

Large-scale Neural Models of Brain Function

Speaker: Sridharan Devarajan

Abstract: The brain is the seat of cognition and intelligent behavior. Discovering how the human brain functions is globally-recognized as a major research frontier of the 21st century. Brain processes occur at various scales: from the level of single molecules and synapses, to the level of neurons and large neural networks, all of which (directly or indirectly) influence organismal behavior. Neuroscientists are increasingly confronted with the challenge of integrating knowledge across these various scales.

Large-scale, biophysically realistic, computational models of the brain enable addressing this challenge. While most large-scale models of the brain are built on massively parallel software architectures, I will describe a different approach: scalable, large-scale neural networks built on neuromorphic hardware (in-silico). I will specifically present simulations conducted on such an in-silico neural model that demonstrate how altering a basic synaptic property, i.e., the inhibitory synaptic time constant, gives rise to an emergent network phenomenon, i.e., neural gamma-band oscillations, that could in turn play a critical role in an important cognitive phenomenon, i.e., the ability to reliably encode information in working memory.

I will conclude by describing recent initiatives at the Centre for Neuroscience at IISc that seek to advance our understanding of brain function through a highly interdisciplinary approach.

Brief Biography: Sridharan Devarajan received his Bachelors and Masters engineering degrees from the Indian Institute of Technology (IIT) Madras. He then moved to Stanford University for his Ph.D. in Neuroscience, where as a Stanford Graduate (Smith)

Fellow he studied the neural dynamics of attention and executive control with functional neuroimaging (fMRI). He subsequently joined Prof. Kwabena Boahens lab in the Department of Bioengineering where he designed and tested computational neural models on neuromorphic chips developed by Prof. Boahens group. He then completed his postdoctoral work as a Dean's Postdoctoral Fellow with Prof.Eric Knudsen in the Department of Neurobiology at Stanford University's School of Medicine, investigating the role of a specific midbrain circuit in attention. He is now an Assistant Professor at the Centre for Neuroscience at IISc where he studies how complex cognitive phenomena, such as attention and decision-making, emerge from elementary neural computations in the human brain.

Session 4

Interdisciplinary Centre Talk : Bioengineering

Session Chair: K. V. S. Hari, ECE, IISc

Bioengineering at IISc

Speaker: S. P. Arun

Abstract: Research on biology related problems is pervasive to different degrees in almost all science and engineering disciplines today; IISc is no exception. The Bioengineering program at IISc now includes 35 faculty members across 16 departments in IISc, together with more than a dozen clinicians from outside IISc. In this talk, I will outline the research undertaken by the bioengineering program in IISc, and describe a specific bioengineering problem in which I am using electrical engineering techniques to understand how the brain solves

Brief Biography: S. P. Arun received his B.Tech from IIT Bombay, and M.S. & Ph.D. from Johns Hopkins University, all in Electrical Engineering. He completed his postdoctoral research at Carnegie Mellon University and joined the Centre for Neuroscience at IISc. His interests are in visual perception and object recognition.

Session 5

Faculty Talk : Supercomputer Education and Research Centre

Session Chair: K. V. S. Hari, ECE, IISc

Role of Computation in a Fundamental Understanding of Optical Processes

Speaker: Murugesan Venkatapathi

Abstract: Computer based models of physical processes are very common in the applied sciences now. They are useful in conception, design and manufacture of devices. A few inconspicuous examples in models of light-matter interaction and their utility will be presented. Computation is also taking on a more fundamental role in our understanding of physical processes. This will be highlighted by an example where computation is indispensable in understanding the optical process.

Brief Biography: Murugesan Venkatapathi pursued his graduate studies at the University of North Carolina and at Purdue University. He joined the department of SERC at Indian Institute of Science in 2009. He currently heads a research group that studies optical properties of materials, matrix algebra, and computational methods.

Session 6

Contributed Session : Algorithms and Applications

Session Chair: Arnab Bhattacharyya (IISc), Rajeev Shorey (TCS Innovation Labs)

6.1 Towards Smart Bandages

Speaker: Prateek Jha

Contact: prateek.jha89@gmail.com

Abstract: A Conformal Active Stretchable Sheet (CAS) is required to enable electronic capability to elastomeric substrate which can then be used in applications like wearable electronics, medical sensors, smart bandages, sensor stamps, IOT stamps etc. Copper is the backbone of our present electronic industry. Crystalline Silicon (CS) technology is at the present state of art. Adopting this technology also enables us to add communication abilities. Adhesion of CS devices to copper is well known. It will be really easy for the community to embrace devices following such a protocol. The procedures to develop such CASs obtained during the research are very simple in nature.

PDMS was used as the substrate and working electronic circuits were developed upon it using copper as the interconnecting material. General CS devices were then soldered to get active sheets.

6.2 Program Repair by Automated Generation of Hints

Speaker: Shalini Kaleeswaran

Contact: shalinikaleeswaran@gmail.com

Abstract: Automated program repair tries to modify a faulty program so that it conforms to a given specification, i.e., the correct computation. Complete repair is often an

unachievable goal. Thus, our work aims to obtain hints or suggestions that help a user repair the program. In this work, we propose two repair techniques: (1) MintHint and (2) DPAssist. MintHint is aimed at software where regression tests are available. MintHint uses these as an incomplete specification and generates useful and effective hints. Another application of repair is to generate feedback for student programming assignments. DPAssist proposes an automated grading technique for dynamic programming (DP) assignments. In an academic setting, the instructor writes a reference implementation which can be used as the specification. The repair takes the form of feedback that helps students understand mistakes in their programs. To be useful, the repair needs to be at a higher level than syntactic transformations.

MintHint performs statistical correlation analysis to identify expressions that are likely to occur in the repaired code and generates repair hints from these expressions, using pattern-matching based synthesis. Developers construct a complete repair using these hints. We conducted a user study to evaluate MintHint and found that developers who used MintHint obtained the repair 5.8 times faster than those who did not.

DPAssist performs syntactic analysis to identify the 3 DP components of the program - initialization, update and the output. Given a reference implementation and a student assignment, it obtains the DP summary of both programs. The student program summary is compared against the reference summary to generate feedback.

Automated repair is a very challenging problem, yet very interesting and useful. Our work advances the state-of-the-art in this field.

6.3 Finding a Subset of Non-defective items from a Large population: Fundamental Limits and Efficient Algorithms

Speaker: Abhay Sharma

Contact: `abhay.bits@gmail.com`

Abstract: Consider a large population containing a small number of "defective" items. A commonly encountered goal is to identify the defective items, for example, to isolate them. In the classical non-adaptive group testing (NAGT) approach, one groups the items into subsets, or pools, and running tests for presence of a defective item on each pool. Using the outcomes the tests, a fundamental goal of group testing is to reliably identify the complete set of defective items with as few tests as possible. In contrast, we study a non-defective subset identification problem, where the primary goal is to identify a "subset" of "non-defective" items given the test outcomes. We derive upper and lower bounds on the number of nonadaptive group tests required to identify a given number of non-defective items with arbitrarily small probability of incorrect identification as the population size goes to infinity. We show that an impressive reduction in the number of tests is achievable compared to the approach of first identifying all the defective items and then picking the required number of non-defective items from the complement set. We also derive a bouquet of computationally efficient and analytically tractable non-defective

subset recovery algorithms. By analyzing the probability of error of the algorithms, we obtain bounds on the number of tests required for non-defective subset recovery with arbitrarily small probability of error.

6.4 Grobner Basis Algorithms for Polynomial Ideal Theory Over Noetherian Rings

Speaker: Maria Francis

Contact: mariafranc@gmail.com

Abstract: The theory of Grobner bases developed by Buchberger (1965) has become a standard tool in computational polynomial ideal theory over fields and algebraic geometry. The main aim of our work is to study and develop Grobner basis algorithms for various computational ideal problems in $A[x_1, \ldots, x_n]$, where A is a Noetherian, commutative ring. The specific cases include polynomial rings over integers, $\mathbb{Z}[x_1, \ldots, x_n]$ and polynomial rings over polynomial rings, $\Bbbk[\theta_1, \ldots, \theta_m][x_1, \ldots, x_n]$.

We consider the problem of determining an A-module basis for the residue class polynomial ring, $A[x_1, \ldots, x_n]/\mathfrak{a}$ that is finitely generated as an A-module. The major challenge here is all ideals in $A[x_1, \ldots, x_n]$ do not lead to a free residue class polynomial ring (unlike in the case of fields). By computing a specific type of Grobner basis called 'short reduced Grobner basis' we arrive at a necessary and sufficient condition for a finitely generated $A[x_1, \ldots, x_n]/\mathfrak{a}$ to be free (Francis & Dukkipati (2014a)). This leads to a generalization of Macaulay-Buchberger basis theorem to the case of Noetherian rings which in turn gives rise to an algorithm to determine the module basis of a residue class ring.

Ideal lattices are integer lattices that are ideals as well in the residue class polynomial rings in $\mathbb{Z}[x]$(Francis & Dukkipati(2014b)). We extend ideal lattices to the multivariate case . We show that $\mathbb{Z}[x_1, \ldots, x_n]/\mathfrak{a}$ has ideal lattices if and only if the short reduced Grobner basis of $\mathfrak{a}$ is monic. We also characterize ideals in $\mathbb{Z}[x_1, \ldots, x_n]$ that give rise to full rank lattices. We establish the existence of collision resistant hash functions based on multivariate ideal lattices using Grobner basis techniques in (Francis & Dukkipati(2014)).

6.5 Algorithm-Architecture Co-design for NLA

Speaker: Farhad Merchant

Contact: farhad@cadl.iisc.ernet.in

Abstract: Algorithms that exhibit time complexity of $O(n^3)$ are challenging to accelerate. On the other hand, architectures are limited by the "Memory Wall", "Power Wall" and "Utilization Wall". In this paper we present algorithm-architecture co-design for NLA. We take matrix multiplication, LU and QR factorizations as a case study in the algorithm space while we take REDEFINE as a platform. The major contributions of

this work are as follows:

1. We optimize algorithms to achieve higher Instruction Level Parallelism (ILP). We use frame fusion to exploit data locality and ILP exhibited by algorithm where frame represents independent computations in parallel
2. Frame fusion generalizes the Givens Rotation (GR) that can annihilate multiple elements of the columns of the matrix simultaneously.
3. We present detailed micro-architectural enhancement for Custom Function Unit (CFU) designed for REDEFINE and achieve 85-90
4. We perform detailed exploration for the pipeline depth of fully pipelined Floating Point Units (adder, multiplier, square root, and divider) and arrive at the optimum pipeline depths of FP Units for NLA domain. We also propose a reconfigurable datapath (DOT4: vector transpose into vector of size 4) and show that the expression encountered in MM, LU and QR factorization can be represented as a canonical set of DOT4.

Finally, we compare our results with some of the recent academic and commercial implementations and show better performance.

Session 7

Interdisciplinary Centre Talk : RBCCPS

Session Chair: Jayant Haritsa, CSA/SERC, IISc

Research to Application : Translating Technology for Impact

Speaker: Jay Warrior

Abstract: The Robert Bosch Centre at IISc focuses on enabling technology to have an impact. Doing this requires many steps and involves many people, both inside and outside IISc. In this talk, we will describe the process that has been evolved at the centre and talk about some of the unique opportunities for IISc researchers that have come up as a consequence. We will present examples of current and past technology transfer projects at the centre and describe some of the current open problems needing solutions. We will also talk about how you can avail of the resources of the centre.

Brief Biography: Jay Warrior has over 20 years of experience creating new high technology driven business opportunities in the US, Europe and Asia for Honeywell, Rosemount, HP and Agilent. Technologies developed by Jay and his teams include the HART protocol, the current defacto field communication standard in industrial automation, several components of the IEEE 1451.X standards for sensor networks, the IEEE 1588 network time synchronization protocol, JDDAC - a multiparty initiative to create an open source environment for distributed data acquisition and control and "smart optics", the core technology behind JDSU's Packet Portal product line for edge measurement in telecommunications networks. His current work focuses on new architectural paradigms for the next generation of IOT - IOT2.

Session 8

Interdisciplinary Centre Talk : CiSTUP

Session Chair: Jayant Haritsa, CSA/SERC, IISc

Problems Related to intelligent Urban Planning - Smart Cities

Speaker: Chandra Kishen

Abstract: The Centre for infrastructure, Sustainable Transportation and Urban Planning (CISTUP) was established in the year 2009 at the Indian Institute of Science with the support of several departments of the Government of Karnataka. The main objectives of the Centre are to conduct basic and applied research, organize training programs, capacity building and develop expertise in the areas of infrastructure, transportation and urban planning.

CiSTUP is involved in research programs which cut across different disciplines including environmental science, ecological sciences, transportation engineering, intelligent and smart systems, water sciences and others which are useful for city planning and development. Studies involving pedestrian underpasses, vehicular overpasses, solid waste management, mitigating air pollution from transportation sources, traffic assessment at different junctions, bus stop and bus bays, auto rickshaw sector, all related to the city of Bangalore have been carried out at this Centre. Detailed reports highlighting recommendations for improving the quality of life of the people have been prepared and submitted to the concerned Government authorities.

In this presentation, the focus would be on the research problems involving the development of smart cities, more specifically on intelligent transport models. Open problems which would be of interest to students of computer science, electrical and communication engineering, electrical systems engineering and product design would be highlighted.

Brief Biography: Prof. Chandra Kishen is professor at Department of Civil Engineering. at Indian Institute of Science. After his B.E. and M.E. in civil engineering at

University College of Engineering, and IISc, Bangalore, he pursued his Ph.D. at University of Colorado, Boulder, USA. He has won many awards like best teaching award at University of Colorado and Prof. Satish Dhawan Young Engineer State Award by Govt. of Karnataka. His research interests are fatigue crack propagation in cementitious materials, Fracture behavior of cementitious materials and cold-jointed interfaces and Residual Life Assessment of Existing Railway Bridges. He has been a consultant in various projects for Indian Railways, Army Welfare Housing Organization, Karnataka Power Corporation Limited, Nuclear Power Corporation, Irrigation Department for Government of Karnataka, Reserve Bank of India, Panchayat Raj Department for Government of Karnataka, Larsen and Toubro, National Highway Authority of India, BBR India, GE India, Godrej Properties Limited, Kirby Building Systems India. He is the chairman of Centre for Scientific and Industrial Consultancy (CSIC), Indian Institute of Science and chairman of Centre for infrastructure, Sustainable Transportation and Urban Planning (CiSTUP), Indian Institute of Science.

Session 9

Faculty Talk : Department of Electronic Systems Engineering

Session Chair: Jayant Haritsa, CSA/SERC, IISc

Proportionally Fair Spatial Aloha for Poisson Networks

Speaker: Chandramani Singh

Abstract: We study topology aware and proportionally fair medium access control in a Poisson network using spatial Aloha. We show that there exists a continuum of adaptive controls based on local stopping sets, with the extreme cases being (1) the case without any topology information and (2) the case with full network topology information. We give fixed point equation for the medium access probability in the general case, and we also derive the associated performance measures. As local information increases, the performance levels of these schemes are shown to get arbitrarily close to that of the full information based scheme.

Brief Biography: Chandramani Singh is an Assistant Professor in Department of ESE. He was a research engineer at TREC, a joint research team between INRIA Rocquencourt and ENS de Paris, from Feb 2012 to Feb 2013, and a postdoctoral research associate at Coordinated Science Laboratory, University of Illinois at Urbana-Champaign, from March 2013 to July 2014. He received ME and PhD degrees from Department of ECE at IISc in 2005 and 2012, respectively. He also worked as a member of technical staff at ESQUBE Communication Solutions Pvt. Ltd. from 2005 to 2006. His research interests include modeling, analysis and control of networks, cloud computing, optimization and game theory.

Session 10

Faculty Talk : Department of Electrical Communication Engineering

Session Chair: Jayant Haritsa, CSA/SERC, IISc

Sequential Decision Making in Complex Environments

Speaker: Aditya Gopalan

Abstract: Sequential decision making or online learning is concerned with studying how an agent can learn to perform a task with repeated actions and feedback, i.e., trial and error. An increasing number of modern-day automated systems are tasked with learning to make decisions by utilizing available data. Take, for instance, learning to personalize content on the Internet - displaying news stories that might interest browsing users, or recommending merchandise that potential shoppers might like - by interacting with users over time, or automated stock trading in which trading decisions are made based on observations of previous trades.

The talk will introduce a widely employed model of decision making under uncertainty called Multi-Armed Bandits, in which a decision maker repeatedly faces a choice of playing one of several "arms" or actions, each with an unknown distribution. We will explore variants of the model, study its history in brief, and review well-known approaches to bandit optimization. We also present recent work in learning with complex feedback structures and parameterized reinforcement learning, and outline emerging directions.

Brief Biography: Aditya Gopalan is an Assistant Professor at the Indian Institute of Science, Electrical Communication Engineering. He received the Ph.D. degree in electrical engineering from The University of Texas at Austin in 2011, and the B.Tech. and M.Tech. degrees in electrical engineering from the Indian Institute of Technology Madras in 2006. He was awarded the 2012 Andrew and Erna Viterbi Post-Doctoral Fellowship at the Technion-Israel Institute of Technology, Israel, and the INSPIRE Faculty Award by the Dept. of Science and Technology, Government of India, in 2014. His research interests include communication networks, learning and control, and performance analysis.

Session 11

Contributed Session : Networks and Games

Session Chair: Chandramani Singh (IISc), Vinayaka Pandit (IBM Research)

11.1 Campaigning in Heterogeneous Social Networks: Optimal Control of Sl Information Epidemics

Speaker: Kundan Kandhway

Contact: kundan.kk@gmail.com

Abstract: We study the optimal control problem of maximizing the spread of an information epidemic on a social network. Information propagation is modeled as a Susceptible-Infected (SI) process and the campaign budget is fixed. Direct recruitment and word-of-mouth incentives are the two strategies to accelerate information spreading (controls). We allow for multiple controls depending on the degree of the nodes/individuals. The solution optimally allocates the scarce resource over the campaign duration and the degree class groups. We study the impact of the degree distribution of the network on the controls and present results for Erdos-Renyi and scale free networks. Results show that more resource is allocated to high degree nodes in the case of scale free networks but medium degree nodes in the case of Erdos-Renyi networks. We study the effects of various model parameters on the optimal strategy and quantify the improvement offered by the optimal strategy over the static and bang-bang control strategies. The effect of the time varying spreading rate on the controls is explored as the interest level of the population in the subject of the campaign may change over time. We show the existence of a solution to the formulated optimal control problem, which has non-linear isoperimetric constraints, using novel techniques that are general and can be used in other similar optimal control problems. This work may be of interest to political, social awareness, or crowd funding campaigners and product marketing managers, and with some modifications may be used for mitigating biological epidemics.

11.2 Ranking from Pairwise Preferences: The Role of the Pairwise Preference Matrix

Speaker: Arun Rajkumar

Contact: vdrn485@gmail.com

Abstract: Ranking from pairwise comparisons has gained a lot of interest recently. Given outcomes of pairwise comparisons among a set of items (movies, sports teams etc), the goal here is to combine these preferences into a global ranking over the items. Several algorithms including the spectral ranking (Page rank), least squares, Matrix Borda, maximum likelihood under the Bradley-Terry model etc have been proposed for this problem. However, not much is understood about when these algorithms perform well. In this work, we consider this problem under three settings. First, we consider a natural generative model where all pairs could be sampled and elucidate conditions under which these algorithms produce an optimal ranking that minimizes the pairwise disagreement error assuming the preferences are acyclic. We propose a SVM based algorithm that produces an optimal ranking under broader conditions than previous algorithms. Second, under the same model, we consider the setting when one can sample all pairs but the preferences may contain cycles. Here obtaining an optimal ranking is in general NP-hard. We propose algorithms which rank 'winners' ahead of the rest, where the winners are based on tournament solution concepts. Third, we consider the setting where the number of items is large and one can sample only $O(nlogn)$ pairs. We propose the Low Rank Pairwise Ranking algorithm based on matrix completion ideas which produces an optimal ranking under broader conditions than previously known results. We obtain explicit sample complexity bounds for all the models considered and validate our theoretical findings using experimental results.

11.3 Multi-armed Bandit Mechanisms

Speaker: Shweta Jain

Contact: jainshweta@csa.iisc.ernet.in

Abstract: Consider a requester who wishes to crowdsource a series of identical binary labeling tasks from a pool of workers so as to achieve an assured accuracy for each task, in a cost optimal way. The workers are heterogeneous with unknown but fixed qualities and their costs are private.

The problem is to select for each task an optimal subset of workers so that the outcome obtained after aggregating labels from them guarantees a target accuracy level. The problem is challenging in a non strategic setting as the accuracy of aggregated label depends on unknown qualities. We develop a novel multi-armed bandit (MAB) mechanism for solving this problem. In particular, we propose a framework, *Assured Accuracy Bandit (AAB)*, which leads to an adaptive, exploration separated MAB algorithm, *Constrained*

Confidence Bound for Non Strategic setting (CCB-NS). We derive an upper bound on the number of exploration steps which depends on the target accuracy level and true qualities. More challenging situation arises when the requester not only has to learn the qualities of the workers but also elicit their true costs. We modify the CCB-NS algorithm to produce an ex-post monotone allocation rule which we call Constrained Confidence Bound for Strategic setting (CCB-S) that can be transformed into an ex-post incentive compatible and ex-post individually rational mechanism that learns qualities of the workers and guarantees the target accuracy level in a cost optimal way.

11.4 Approximate Dynamic Programming

Speaker: Chandrashekar L.

Contact: chandrurec5@gmail.com

Abstract: Markov decision processes (MDPs) with large number of states are of high practical interest. However, conventional algorithms to solve MDP are computationally infeasible in this scenario. Approximate dynamic programming (ADP) methods tackle this issue by computing approximate solutions. Most ADP methods employ linear function approximation (LFA), i.e., the approximate solution lies in a subspace spanned by a family of pre-selected basis functions. An important shortcoming of most ADP methods based on conventional LFA is that the prediction error is bound only in the L_2 norm and the convergence of policy is not guaranteed. The first part of the work comprises of exploring ADP methods in the (min,+) linear basis wherein we show that both the prediction error and the control error can be bound in the L_∞ norm. In the second part of the work we solve the long standing problem of understanding constraint reduction in a widely applied ADP method called the approximate linear program (ALP). Though the ALP offers theoretical guarantees for both prediction and control, the ALP is difficult to solve due to the presence of a large number of constraints. In practice, a reduced linear program (RLP) formulated by sampling constraints from the ALP is solved instead and has found to perform well in experiments. However, the theoretical guarantees are available only for a specific RLP obtained under idealized assumptions. We generalize the RLP to define a generalized reduced linear program (GRLP) and develop a novel theoretical framework to obtain error bounds for any given GRLP.

11.5 Models and Methods for Formation and Analysis of Social Networks

Speaker: Swapnil Dhamal

Contact: swapnil.dhamal@gmail.com

Abstract: This doctoral dissertation addresses problems in three important domains of social networks research, namely, 1. Network formation, 2. Preference aggregation,

and 3. Information diffusion. This presentation will focus on multi-phase information diffusion in social networks.

In the problem of maximizing information diffusion, given a certain budget (number of seed nodes where diffusion should be triggered), it is generally assumed that all the seed nodes are selected and activated at the beginning of the diffusion. This paper investigates the effects of selecting and activating the seed nodes in multiple phases. In particular, we study diffusion in two phases under the well-studied independent cascade model. We formulate an appropriate objective function for two-phase diffusion, investigate its properties, and propose suitable algorithms for determining the seed nodes in the two phases. We observe that two-phase diffusion, on an average, outperforms single-phase diffusion by about 10 percent in the absence of temporal constraints. We also study two associated problems: (1) budget splitting: determining how to split the total budget between the two phases and (2) scheduling: determining the delay after which the second phase should be triggered. Our main conclusions are the following: (a) under strict temporal constraints, use single-phase diffusion, (b) under moderate temporal constraints, use two-phase diffusion with a short delay while allocating most of the budget to the first phase, and (c) when there are no temporal constraints, use two-phase diffusion with a long enough delay with almost equal budget for the two phases.

11.6 Mechanism Design with Interdependent Values

Speaker: Satyanath Bhat

Contact: satya.bhat@gmail.com

Abstract: We consider an expert-sourcing problem where the owner of a task benefits from high quality opinions provided by experts. Execution of the task at an assured quality level in a cost effective manner becomes a mechanism design problem when the individual qualities are private information of the experts. The considered class of task execution problems falls into the category of interdependent values, where one cannot simultaneously achieve truthfulness and efficiency in the unrestricted setting due to an impossibility result. We propose a novel mechanism QUEST, that exploits the structure of our special class of problems and guarantees allocative efficiency, ex-post incentive compatibility, and strict budget balance. Our mechanism satisfies ex-post individual rationality for the experts and we also derive the weakest sufficient condition under which it is ex-post individual rationality for the center as well.

11.7 Truthful Crowdsourcing Mechanisms with Application to Geo-Sensing

Speaker: Pankaj Dayama

Contact: pankajdayama@gmail.com

Abstract: The varying nature of qualities and costs of the crowdworkers makes task allocation a non-trivial problem in almost all crowdsourcing applications. If crowd workers are strategic about their costs, the problem becomes even more challenging. Interestingly, in several crowdsourcing applications, for example, traffic monitoring, air pollution monitoring, digital epidemiology, smart grids operations etc., the structure of the tasks in space or time exhibits a natural linear ordering. Motivated by the above observation, we model the problem of task allocation to strategic crowd workers as an interval cover mechanism design problem. In this mechanism, a planner (or task requester) needs to crowd source labels for a set of tasks in a cost effective manner and make a high quality inference. We consider two different scenarios in this problem: homogeneous and heterogeneous, based on the qualities of crowd workers. We show that the task allocation problem is polynomial time solvable in the homogeneous case while it is NP-hard in the heterogeneous case. When the crowdworkers are strategic about their costs, we design truthful mechanisms for both the scenarios. In particular, for the heterogeneous case, we propose a novel approximation algorithm that is monotone, leading to a truthful interval cover mechanism via appropriate payments.

Session 12

Contributed Session : Machine Learning and Vision

Session Chair: Partha Pratim Talukdar (IISc), T. Ravindra Babu (Flipkart)

12.1 High Quality Photometric Reconstruction using a Structured-light Stereo Depth Camera

Speaker: Avishek Chatterjee

Contact: avishek@ee.iisc.ernet.in

Abstract: Recovering the 3D shape of a scene is an enduring problem in computer vision. Two of the classical approaches for recovering the 3D structure of the world are methods that triangulate two rays (stereo) and methods that recover the surface normal by imaging under varying illumination (photometry). Most of the recently available 3D or depth cameras like the Microsoft Kinect rely on the former method, i.e., structured light stereo. The raw depth data obtained from such a camera is rather poor in quality and can be complemented using photometric methods that recover fine scale structural details of surface shape. In our approach, we develop an adaptive fusion method that combines raw depth data with surface normal estimates to obtain a high-quality 3D reconstruction. These two sources of surface shape information complement each other, i.e. one has good low frequency fidelity while the other has good high frequency detail. Apart from the quality of our results, a significant novelty of our approach is that both depth and surface normals are obtained using the same depth camera. We also extend our approach to naturally work with general objects that have multiple albedo ("intrinsic colour"). The factorization method developed for such an extension is shown to be convergent and yields highly accurate 3D reconstructions of a wide variety of objects.

12.2 Action Recognition in Videos using Trajectory Descriptors

Speaker: Sanath Narayan

Contact: `sanath@ee.iisc.ernet.in`

Abstract: My doctoral thesis explores recognizing human actions in real-world, unconstrained videos. Recognizing actions is an important task in applications such as video retrieval, surveillance, human-robot interactions, analysis of sports videos, summarization of videos, etc. Firstly, action recognition in videos captured in normal third-person perspective (view) is investigated. Causal dependencies (based on Granger Causality)between motion trajectories are used to build novel action descriptors and are used in supervised classification setting to recognize the actions. Next, we introduce a motion segmentation method to estimate the camera motion in videos. This helps in identifying the background motion in videos captured by moving cameras. This is a necessary preprocessing step for videos shot using wearable cameras where unintended head-motion is frequent. Recognizing actions in a first-person perspective is also necessary, since there has been an increase in videos being captured from wearable or head-mounted cameras. Thus, we next explore action recognition approaches in first-person (egocentric) views. We have introduced a first-person action recognition dataset for this purpose. And lastly, we extend the single-camera egocentric recognition to recognizing actions in a multi-camera setting with both first-person and third-person views being available. We have also introduced a multi-camera dataset for this purpose. We use a novel inter-perspective causality approach to fuse the action information from different camera perspectives. Our approaches are mainly based on the motion trajectories and their associated features.

12.3 Consistent Algorithms for Multiclass Learning Problems under General Loss Matrices

Speaker: Harish Guruprasad Ramaswamy

Contact: `harish_gurup@csa.iisc.ernet.in`

Abstract: A learning algorithm is said to be 'statistically consistent' if it returns the 'optimal' classifier in the limit of infinite data. Statistical consistency is a fundamental notion in supervised machine learning and therefore an important question is the design of consistent algorithms for various learning problems. While this has been well studied for binary classification and some other specific learning problems, the question of consistent algorithms for general multiclass learning problems remains open. We investigate 3 aspects of this question detailed below.

1) We build a framework for studying consistent algorithms w.r.t. a multiclass loss matrix and define a fundamental quantity called the convex calibration dimension of a loss matrix, which represents the intrinsic difficulty of designing consistent algorithms for a given loss matrix. We derive upper and lower bounds on this quantity and give

implications on various specific problems.

2) We construct an explicit generic least squares type consistent algorithm for any given loss matrix whose dimension depends only on the linear algebraic rank of the loss matrix. We apply this result to various loss matrices used in subset ranking and derive consistent algorithms.

3) We construct (better than generic) consistent convex optimization based algorithms for two specific problems of practical interest the abstain loss and the tree distance loss. The abstain loss is useful in applications where abstaining from predicting is a good option in the face of uncertainty e.g. medical diagnosis. The tree-distance loss is used in hierarchical classification.

12.4 Algorithms for Reinforcement Learning

Speaker: Prabuchandran K.J.

Contact: `prabu.kj@csa.iisc.ernet.in`

Abstract: Reinforcement learning (RL) methods are simulation based approaches for solving sequential decision making problems under uncertainty that are commonly modeled as Markov Decision Processes (MDPs). The standard Dynamic Programming (DP) solution approach requires a complete model of the MDP and is applicable only for MDPs with small state-action space. RL algorithms, on the other hand, are used in model-free situations. The use of function approximation technique in RL algorithms makes it a powerful tool for solving MDPs with large state-action spaces, however, this comes with an associated problem of choosing the right features for approximation. In my research, we develop novel RL algorithms to tune the features online to obtain best features for approximation. Also, we study the applications of the RL algorithms to real world problems in the areas of sensor networks and vehicular traffic control.

Initially, we solved the problem of choosing the best features for the prediction problem (or policy evaluation) of a discounted cost MDP. Subsequently, we developed RL algorithms for the control problem that incorporate feature adaptation, under both the weighted discounted cost as well as the average cost MDP frameworks.

We also applied RL algorithms to find the optimal energy management policy for a single energy harvesting sensor node in a wireless sensor network application. The RL algorithms we applied do not scale when there are multiple sensor nodes. In the subsequent work, we developed RL algorithms with function approximation for energy sharing in multiple sensor nodes.

In the application of RL algorithms to vehicular traffic control, we formulated the problem of intelligently controlling traffic lights as discounted cost MDP and developed multi-agent reinforcement learning (MARL) algorithms to reduce the average delay experienced by the road users.

12.5 Discovering Compressing Serial Episodes from Event Sequences

Speaker: Ibrahim A

Contact: `ibrahim@ee.iisc.ernet.in`

Abstract: Frequent pattern mining is an important subfield of data mining with lots of applications. It is the process of extracting interesting latent patterns in the data, where a pattern could signify depending upon the type of the data, some local structure or dependencies among certain variables of attributes of the data. Two of the major challenges of frequent pattern mining is the efficient mining of frequent patterns, the size of which could be very large and selecting a small subset of non-redundant patterns, which could best represent the data. We first introduce the Pattern-Growth approach for mining a class of patterns retrieved from temporal data called frequent serial episodes. We see how the pattern-growth approach differs from the traditional apriori methods. We then propose a scheme for finding a small set of non redundant serial episodes, that summarizes and represents the data set well, using the Minimum Description Length (MDL) principle. The effectiveness of the selected serial episodes by our method over other summarization based schemes is shown with respect to three criteria: the interpretability of the patterns with respect to the data, the compression achieved while encoding the data using the selected serial episodes and the accuracy achieved in classification when the selected serial episodes are used as features.

Session 13

Keynote Talk : Tejas Networks

Session Chair: P. S. Sastry, EE, IISc

Opportunities to Make an Impact in Telecommunications

Speaker: Kumar N. Sivarajan

Abstract: The top buzzwords in telecom today are IoT, 5G and SDN. First, I will briefly review these notions and discuss how they can transform the telecom networks of today. Then, I will discuss what we can do, especially from India, to make an impact in these areas. Finally, I will summarize our experience in developing Tejas Networks over the last 15 years into a telecom product company from Bangalore.

Brief Biography: Kumar N. Sivarajan serves as the Chief Technology Officer and is responsible for setting the technology and product direction for Tejas Networks. Prior to cofounding Tejas Networks, Kumar was an Associate Professor in the ECE Department, at IISc, and has recently rejoined ECE as an Adjunct Faculty member. Earlier he has worked with the IBM Thomas J. Watson Research Center, Yorktown Heights, New York.

Kumar is co-author of the textbook 'Optical Networks: A Practical Perspective' published in February 1998. He is a Fellow of the Indian National Academy of Engineering and a recipient of the Swarnajayanti Fellowship from the Department of Science & Technology. He is also a recipient of the IEEE Fortescue Fellowship and the IEEE Baker Prize Paper Award.

Kumar holds a B. Tech. in EE (Electronics) from IIT, Madras, and a Ph.D. in EE from the California Institute of Technology. He is a distinguished alumnus of IIT, Madras.

Session 14

Faculty Talk : Department of Electrical Engineering

Session Chair: P. S. Sastry, EE, IISc

Localization of Point Clouds from Incomplete Distances: Review and Recent Progress

Speaker: Kunal Chaudhury

Abstract: We consider the problem of positioning a point cloud in an Euclidean space from a subset of pairwise distances. This problem comes up in various applications including ad-hoc localization of sensor networks and the calculation of protein conformations from NMR measurements. It is also closely related to dimensionality reduction and manifold learning, where the goal is to learn the underlying geometry of a data set using local metric information.

In this talk, we will look at some of the fundamental "existence" questions associated with this problem and the recent progress that has been made in addressing these questions. We will also look at some recent algorithms (based on spectral and convex approximations) that can provably solve this otherwise non-convex problem under appropriate assumptions.

Brief Biography: Kunal Chaudhury is currently an Assistant Professor in the Department of Electrical Engineering at the Indian Institute of Science. Prior to joining the institute, he was a Swiss National Science Foundation Fellow and then a Research Associate in the Program in Applied and Computational Mathematics at Princeton University. Kunal's research interest is in inverse problems in image analysis and processing, design of fast and scalable algorithms for image and video processing, large-scale sensor network localization, protein structure calculation, and convex optimization. Kunal has an M.E. in System Science and Automation from IISc, and a Ph.D. in Computers, Communication, and Information Systems from Ecole Polytechnique, Switzerland.

Session 15

Faculty Talk : Department of Computer Science and Automation

Session Chair: P. S. Sastry, EE, IISc

Updatability of Error Correcting Codes

Speaker: Bhavana Kanukurthi

Abstract: Error correcting codes are a powerful tool for obtaining reliability in the storage and transmission of data. In this talk, I will discuss the notion of updatability of error correcting codes, specifically by introducing locally updatable and locally decodable codes. These are codes which have a low decode locality. In addition, they allow us to update a codeword (of a message) to a codeword of a different message, by rewriting just a few symbols. While, intuitively, updatability and error-correction seem to be contrasting goals, I show a suitable model for which one can construct such codes. Finally, I will discuss how our techniques apply to the setting of dynamic proofs of retrievability.

Brief Biography: Bhavana Kanukurthi is an Assistant Professor in the Department of Computer Science and Automation at the Indian Institute of Science. Bhavana's area of research is Cryptography. Previously, she was a post-doctoral researcher at UCLA hosted by Prof. Rafail Ostrovsky. Bhavana obtained her Ph.D. in Computer Science in 2011 from Boston University, where she was the recipient of a Research Excellence Award. Her doctoral research was advised by Prof. Leonid Reyzin. She has held internship appointments at Microsoft Research, New England and Bell Labs, New Jersey.

Session 16

Contributed Session : Communications

Session Chair: Himanshu Tyagi (IISc), Aditya Karnik (GE Research)

16.1 Fast Solvers for Electromagnetic Applications

Speaker: Arkaprovo Das

Contact: arka_reek@yahoo.co.in

Abstract: Electromagnetics is an indispensable branch of science which has given birth to a plethora of applications. Some applications are classical which includes communication technologies like cellular communication, wifi, bluetooth etc., while some are medical in nature with the advent of radio frequency (RF) sensor technologies, and are extensively used in the field of bio-medical imaging. Some applications on the other hand are strategic and include defence, military and space technologies, with large antennas and radars used for the purpose. The variety of applications that electromagnetics caters to, requires extensive simulation methodologies to deal with practical real-world scenarios. The range of simulation thus extends from micro and nano-scale as in chip-package-board systems to macro level technologies such as stealth technology, wide area surveillance, RF remote sensing and so on. This calls for the need of fast, efficient, accurate and robust electromagnetic solvers. This presentation will focus on fast solvers for day to day electromagnetic applications. It will highlight the techniques to solve a large electromagnetic problem in lesser time by either using fast linear-complexity algorithms or by ways to reduce the number of unknown solution variables efficiently and optimally. The presentation will cover a research-perspective overview of the entire problem and will also highlight the role of having well-conditioned systems for fast solutions.

16.2 Physical Layer Data Fusion Algorithms for Cognitive Radio applications

Speaker: Venugopalakrishna Y. R.

Contact: vgkrishnayr@gmail.com

Abstract: In this work, data combining based algorithms are proposed for the following three applications of Cognitive Radios (CRs): 1. Cooperative spectrum sensing using binary consensus. 2. Communication footprint construction to assist geo-databases. 3. Self-localization of CRs.

First, the problem of achieving binary consensus among a set of wireless nodes using physical layer protocols is considered. A co-phased combining based scheme is studied under imperfect CSI at the nodes. The evolution of network consensus is modeled as a Markov chain, and the average transition probability matrix is analytically derived. The average hitting time and average consensus duration are used to characterize the stopping time of the consensus procedure.

Second, using the fact that a typical communication footprint is sparse, two novel compressed sensing based schemes are proposed to quickly construct the spectrum map using 1-bit decisions from sensors deployed in a geographical area. Also, the number of primary transmitters is determined using a combination of the K-means algorithm and a circular fitting technique, and, a design procedure is proposed to determine the power thresholds for signal detection at sensors.

Next, we consider the problem of self-localization of a target node using beacon nodes. The geographical area is overlaid with a virtual grid, and the problem of localization is treated as one of testing overlapping subsets of grid cells for the presence of the target node. The target node localizes using measured received power from various beacons and a binary radio footprint that was constructed offline.

16.3 Optimal Power Allocation for Protective Jamming in Wireless Networks: A Flow Based Model

Speaker: Siddhartha Sarma

Contact: siddhartha.sarma@gmail.com

Abstract: The problem of eavesdropping in Wireless Networks is well-known and well-studied. While the current trend is to use cryptographic techniques, we address this problem using the technique of friendly jamming for multi-hop wireless networks. The significance of jamming to improve the secrecy of transmission is well-established in the "Physical Layer Security" literature. Motivated by that, we propose a flow based formulation to provide data security with the help of friendly jamming nodes. The network is assumed to employ decode and forward (DF) relaying. Assuming the availability of perfect channel state information (CSI) of legitimate nodes and eavesdroppers, we consider a scheduling and power allocation (PA)

problem for a multiple-source multiple-sink scenario, so that eavesdroppers are jammed and source-destination throughput targets are met, while minimizing the overall transmitted power. We propose activation sets (AS-es) for scheduling, and formulate an optimization problem for power allocation. Several methods for finding AS-es are discussed and compared. We present an approximate linear program for the original non-linear, non-convex PA optimization problem, and argue that under certain conditions, both the formulations produce identical results. In the absence of eavesdroppers' CSI, we utilize the notion of vulnerability region (VR), and formulate an optimization problem with the objective of minimizing the VR. Our results show that the proposed solution can achieve power-efficient operation while defeating eavesdroppers and achieving desired source-destination throughputs simultaneously.

16.4 Role of Power-Control in Enhancing the Performance of Opportunistic Selection Schemes

Speaker: Vikas Kumar Dewangan

Contact: dewangan.vikaskumar@gmail.com

Abstract: Opportunistic selection reaps the benefits of multi-user diversity in many wireless applications. In it, the best node is selected for data transmission. The ability of a node to improve the system performance is quantified by a real-valued metric. The best node is the one with the highest metric. Since the nodes are geographically separated, no node knows beforehand who the best node is. Hence, distributed selection schemes are required.

We investigate the role of power control in distributed selection schemes. Power control allows the nodes to choose their target receive power from L pre-specified power levels. These levels are set such that a node can be selected even if up to other nodes transmit with it but do so with lower power levels. First, we propose a timer scheme with power control. In it, each node sets its timer and its target receive power based on its metric. We give an optimal metric-to-timer-and-power mapping, which maximizes the probability of selecting the best node. We show that the scheme significantly outperforms the conventional timer scheme.

We then evaluate the performance of selection schemes with power control, namely, timer based scheme with power control and splitting based scheme with power control under imperfect power control, which randomly changes a node's receive power. We investigate its implications on system throughput. We also evaluate the effect of peak power constraint on the performance of the above schemes.

16.5 Fundamental Limits of Communication in Interference Limited Environments

Speaker: Parthajit Mohapatra

Contact: parthajit.mohapatra@gmail.com

Abstract: The interference channel (IC) is one of the simplest information theoretic models

to analyze the effect of interference on the throughput and secrecy of individual messages in a multi-user setup. In this thesis, the IC is studied under different settings without and with the secrecy constraint. The main contributions of the thesis are as follows:

1. In the initial part of the thesis, the effect of multiple antennas at the transmitter and receiver on the generalized degrees of freedom (GDOF) of the K-user MIMO Gaussian IC (GIC) is investigated. Inner bounds and outer bounds on the GDOF are derived as a function of the number of antennas and the log(INR)/log(SNR) level.

2. Then, the problem of designing the precoding and receive filtering matrices for interference alignment (IA) is explored for the K-user MIMO GIC. Two algorithms for approximately achieving the gain promised by IA are proposed. Also, a new performance metric is introduced to capture the possible loss in signal dimension while designing the precoders.

3. In the third and final part of the thesis, a 2-user IC with rate-limited transmitter cooperation is studied, to investigate the role of cooperation in managing interference and ensuring secrecy. First, a deterministic model of 2-user Gaussian symmetric IC (GSIC) with transmitter cooperation is studied. Achievable schemes and outer bounds are derived. Using the intuitions gained from the deterministic case, achievable schemes and outer bounds are obtained for the GSIC.

16.6 Impromptu Deployment of Wireless Sensor Networks

Speaker: Arpan Chattopadhyay

Contact: `arpanc.ju@gmail.com`

Abstract: We consider the problem of impromptu or as-you-go deployment of wireless sensor networks. A person walks along a line, starting from a sink (resp., source) node, and placing relay nodes as he walks towards a source (resp., sink) location at an a priori unknown distance. A node (source or sink) has to be placed at the end of the line. The sink node could be a base station, whereas the source node could be a sensor node.

We start with impromptu deployment of relay nodes along a line, in order to carry light traffic. A deployment agent starts walking from the sink node, makes link quality measurements at discrete locations to the previously placed relay nodes, and opportunistically deploys relay nodes at some of these locations. The goal is to minimize the mean power used in the network per unit distance, subject to constraints on the quality of service and the relay placement rate. We formulate the problem as optimal sequential decision problems, and establish the optimal policy structure. Next, we develop some learning algorithms that adaptively updates the deployment policy (by learning the unknown wireless propagation environment); we prove that the sequence of policies converge to the optimal policy.

Next, we focus on the development of impromptu deployment strategy in order to maximize the end-to-end data rate. We use information-theoretic achievable rate formulae for the multi-relay channel (with full-duplex radios and decode-and-forward relaying). A deployment agent walks from the source to the sink, deploying relays as he walks, given the knowledge of the wireless path-loss model, and given the distribution of the distance to the sink node. We formulate

the problem as a sequential decision problem with a constraint on the sum power used in the deployed network. We provide analytical results on the computation of the optimal policy, and numerical results on the optimal policy structure and performance of the deployed network.

16.7 Trade-offs and Performance Analysis of Energy Harvesting Wireless Sensor Networks

Speaker: Shilpa Rao

Contact: devashilpa@gmail.com

Abstract: Energy harvesting (EH) is a green alternative to the limited lifetime problem in wireless sensor networks (WSNs). Unlike conventional nodes that drain out their batteries and die, EH nodes recharge their batteries by harvesting the ambient energy. We focus on the energy-efficient design of WSNs that exploit EH, and investigate the new design trade-offs that arise in them. To this end, firstly, we compare the performance of conventional, all-EH, and hybrid WSNs, which consist of both conventional and EH nodes. We then study the max function computation, which aims at energy-efficient data aggregation, in EH WSNs. This has applications in environmental, health, and industrial monitoring.

We first argue that the conventional performance criteria used for evaluating WSNs, which are motivated by lifetime, and for evaluating EH networks are at odds with each other and unsuitable for evaluating hybrid WSNs. We propose new and insightful performance criteria called the k-outage and n-transmission durations to evaluate and compare different WSNs. We prove two computationally-efficient bounds for evaluating these criteria, and show their applications.

Next, we analyze the mean absolute error (MAE) in estimating the maximum reading when a random subset of nodes periodically transmit their readings to the fusion node. We determine the optimal transmit power and the number of scheduled nodes that minimize the MAE, both in the presence and absence of channel state information for quantized and unquantized readings.

Altogether, we develop optimal WSN designs to efficiently utilize the scarce and randomly available energy in fading environments.

16.8 Spectrum Sensing Techniques for Cognitive Radio Applications

Speaker: Sanjeev G

Contact: sanjeev.g@ece.iisc.ernet.in

Abstract: Spectrum Sensing is a first step in the operation of a Cognitive Radio (CR). In this talk, we present Spectrum Sensing (SS) techniques for a variety of practically relevant CR scenarios.

The first scenario is SS in the context of the IEEE802.22 standard. In this, the primary

system uses a wideband signal, with a strong pilot tone. Hence, there are two options for signal detection. First, a narrowband filter can be used to detect based on the pilot energy. Alternatively, the energy in the entire wideband can be used. To answer a natural question of which scheme is better suited for CR applications, we introduce a novel concept called the Error Exponent with a Confidence Level (EECL), and derive the expressions for EECL for both detection schemes, under a decentralized detection set-up.

Another challenge emerges when the primary employs frequency-hopping communication. Here, we obtain the detection performance of the Fast Fourier Transform (FFT) Averaging Ratio (FAR) algorithm in closed form. The effective throughput of the CR system is formulated as a constrained optimization problem. Implementation details of the FAR algorithm on a hardware platform is also presented.

Finally, when the primary signal and fading statistics are not known at the CR, using the statistics of the number of zero-crossings in the observations, we propose a novel goodness-of-fit test for SS, which is robust to noise model and parameter uncertainties and with the computational complexity comparable to a simple energy-based detector.

Session 17

Valedictory and Alumni Meet

Session Chair: R. Govindarajan (SERC), Joy Kuri (DESE)

The alumni of the Departments of CSA, ECE, EE, DESE, and SERC are at the forefront of research and development in EECS and related fields within India and internationally. The alumni of these departments include renowned academicians, leaders in computer and IT industry, distinguished scientists, and trendsetting entrepreneurs.

The Alumni Event is being organized starting from 6.15 PM on Friday, February 13th in the Faculty Hall, IISc Campus. The objectives of this meeting include:

- Providing an update to our alumni about the activities, achievements, and requirements of the five departments
- Enabling an exchange of ideas between (a) the faculty members and students and (b) the alumni
- Eliciting suggestions and ideas from the alumni

Professor Anurag Kumar, Director, IISc, will be addressing the audience during the alumni event. The event concludes with a dinner at the main guest house lawns.

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