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Monday, December 22

7:30 AM - 8:00 AM

Registration - D1: Registration

8:00 AM - 9:30 AM

D1S1-1: Intelligent Machines and Man-machine Co-existence

Room: Salon Jasmine
Chairs: Thrishantha Nanayakkara (King's College, University of London, United Kingdom), Anjula De Silva (University of Moratuwa, Sri Lanka)

D1S1-1.1 8:00 ***Locating Tables in Scanned Documents for Reconstructing and Republishing*** *1*

Akmal Jahan (University of Peradeniya & South Eastern University of Sri Lanka, Sri Lanka); Roshan G. Ragel (University of Peradeniya & University of New South Wales, Sri Lanka)

Pool of knowledge available to the mankind depends on the source of learning resources, which can vary from ancient printed documents to present electronic material. The rapid conversion of material available in traditional libraries to digital form needs a significant amount of work if we are to maintain the format and the look of the electronic documents as same as their printed counterparts. Most of the printed documents contain not only characters and its formatting but also some associated non text objects such as tables, charts and graphical objects. It is challenging to detect them and to concentrate on the format preservation of the contents while reproducing them. To address this issue, we propose an algorithm using local thresholds for word space and line height to locate and extract all categories of tables from scanned images. From the experiments performed on 298 documents, we conclude that our algorithm has an overall accuracy of about 75% in detecting tables from the scanned images. Since the algorithm does not completely depend on rule lines, it can detect all categories of tables in a range of scanned documents with different font types, styles and sizes to extract their formatting features. Moreover, the algorithm can be applied to locate tables in multi column layouts with small modification in layout analysis. Treating tables with their existing formatting features will tremendously help the reproducing of printed documents for reprinting and updating purposes.

D1S1-1.2 8:15 ***A Fuzzy Based Model to Identify Printed Sinhala Characters*** *7*

Gihani Gunarathna and Pathum Chamikara (University of Peradeniya, Sri Lanka); Roshan G. Ragel (University of Peradeniya & University of New South Wales, Sri Lanka)

Character recognition techniques for printed documents are widely used for English language. However, the systems that are implemented to recognize Asian languages, struggle to increase the accuracy of recognition. Among other Asian languages (such as Arabic, Tamil, Chinese), Sinhala characters are unique, mainly because they are round in shape. This unique feature makes it a challenge to extend the prevailing techniques to improve recognition of Sinhala characters. Therefore, little attention has been given to improve accuracy of Sinhala character recognition. A novel method that makes use of this unique feature could be advantageous over other methods. This paper describes the use of a fuzzy inference system to recognize Sinhala characters. Feature extraction is mainly focused on distance and intersection measurements in different directions from the center of the letters, making use of the round shape of characters. The results showed an overall accuracy of 90.7% for 140 instances of letters tested, much better than the similar systems.

D1S1-1.3 8:30 ***A Structured Hardware Software Architecture for Peptide Based Diagnosis of Baylisascaris Procyonis Infection*** *13*

Sugandima Vidanagamachchi and Shirley Devapriya Dewasurendra (University of Peradeniya, Sri Lanka); Roshan G. Ragel (University of Peradeniya & University of New South Wales, Sri Lanka); Mahesan Niranjan (University of Southampton, United Kingdom)

The problem of inferring proteins from complex peptide cocktails (digestion products of biological samples) in shotgun proteomic workflow sets extreme demands on computational resources in respect of the required very high processing throughputs, rapid processing rates and reliability of results. This is exacerbated by the fact that, in general, a given protein cannot be defined by a fixed sequence of amino acids due to the existence of splice variants and isoforms of that protein. Therefore, the problem of protein inference could be considered as one of identifying sequences of amino acids with some limited tolerance. Two problems arise from this: a) due to these (permitted) variations, the applicability of exact string matching methodologies could be questioned and b) the difficulty of defining a reference (peptide/amino acid) sequence for a particular set of proteins that are functionally indistinguishable, but with some variation in features. We will be reporting details of this development in a sequel paper. In the current paper we present a model-based hardware acceleration of a structured and practical inference approach that we have developed and validated to solve the inference problem in a mass spectrometry experiment of realistic size We have achieved 10 times maximum speed-up in the co-designed workflow compared to a similar workflow purely run on the processor used for co-design.

D1S1-1.4 8:45 ***Object Identification, Enhancement and Tracking Under Dynamic Background Conditions*** *20*

Sarith K Fernando, Samitha Herath, Pramuditha Perera, Gunawath Mudiyanselage Roshan Indika Godaliyadda, Mervyn Parakrama Ekanayake and Janaka Wijayakulasooriya (University of Peradeniya, Sri Lanka)

A real-time event tracking method is proposed that is immune to background variances. The proposed method models each pixel as a collection of Gaussian distributions to handle background variations and uses manipulations in the RGB space to mitigate the effects of foreground shadows. A two stepped connected component analysis method is also introduced in refining the estimated foreground and clustering pixels into silhouettes based on objects. Pixel clusters are formed by filling inter-cluster pixels on the basis of neighborhood solidity of individual pixels. Clustered pixels are defined as object fragments and objects are formed by combining object fragments considering their size and mutual distances. The proposed tracker employs an algorithm to boil down the multiple object interaction problems (objects merging, objects splitting, new object appearance and lost objects) into a simple matrix interpretation problem to construct a consistent feature space. Specifically, splitting of merged objects and temporary disappearances of objects due to occlusions with background objects are handled by the means of a feature correspondence matching. A novel object identification method is proposed for this purpose.

D1S1-1.5 9:00 ***Synthesizing Fuzzy Linguistic Vocal Responses by Adapting Perception of Robot Based on Visual Attention*** *26*

Viraj Muthugala and Buddhika Prabhath Jayasekara (University of Moratuwa, Sri Lanka)

This paper proposes a method for adapting robot's perception to produce fuzzy vocal responses about the size of an object based on the visual attention of the robot. In a human-human interaction, the humans may use vocal responses, which have qualitative terms such as "small", "large" etc. The actual quantitative meaning of those terms depends on spatial arrangement of the environment where the attention is focused on. Therefore, spatial information of the environment is analyzed to adapt robot's perception about the size of an object, which is in its vision field. A fuzzy logic based adaptive method has been introduced to build up relationship between qualitative terms and quantitative meaning. The proposed method is capable of adapting its perception to synthesize vocal responses that have uncertain qualitative terms. It has been implemented and tested on interactive robotic head (IRH). A survey has been conducted using human participants to identify actual human perceptions on test scenarios. Results of the developed system and the survey have been analyzed and outcome statistics are presented.

D1S1-2: Robotics, Automation and Control

Room: Orchid
Chairs: Tomoyuki Shimono (Yokohama National University, Japan), Rohan Munasinghe (University of Moratuwa, Sri Lanka)

D1S1-2.1 8:00 ***Reduced Jerk Joint Space Trajectory Planning Method Using 5-3-5 Spline for Robot Manipulators*** *32*

Chinthaka D Porawagama Gamage (University of Moratuwa Faculty of Engineering, USA); Rohan Munasinghe (University of Moratuwa & Faculty of Engineering, Sri Lanka)

A new trajectory planning method for generating bounded and continuous jerk trajectories in joint space has been developed and tested. In manipulator trajectory planning, reduced jerk trajectories are desired for path tracking and vibration suppression. The proposed interpolation algorithm in this research generates a spline, composed with 5th-order, 3rd-order and 5th-order polynomial segments (5-3-5 spline), which can be used for point-to-point trajectories and trajectories with via points. The generated trajectories are continuously differentiable in position, velocity, acceleration, and has a start and end zero-bounded continuous jerk profile. The algorithm allows the user to independently define the position, velocity, acceleration and jerk values at both start and end points, via point positions and velocities, and also, the timing durations for every polynomial segment. These higher number of user definable parameters in the proposed 5-3-5 spline algorithm gives the flexibility for generating trajectories for various motion characteristics. Generated trajectories were tested successfully on DENSO VP6 robot arm. The experimental results are presented.

D1S1-2.2 8:15 ***Redundant Upper Limb Exoskeleton Robot with Passive Compliance*** *38*

Malin Gunasekara, R. A. Ruwan Chandra Gopura and T. S. S. Jayawardane (University of Moratuwa, Sri Lanka)

Enhancing physical Human-Robot Interaction (pHRI) is an important design aspect specially, in upper limb exoskeleton robots. The level of manipulation provided by exoskeleton robot has a significant effect to perform daily tasks. This paper presents a performance evaluation of a 6 degree of freedom (DoF) upper limb exoskeleton robot for motion assist. The details of mechanical design of the robot are presented and novel features are addressed in the robot in order to improve the pHRI. The structure of the exoskeleton robot consists with total of six DoF and two flexible bellow coupling joints are used to provide translational DoF at wrist and elbow joint of robot. Moreover, flexible bellow couplings are positioned at specific locations in order to enhance the kinematic redundancy. The benefit of availability of compliance due to presence of flexible bellow coupling at wrist joint of the exoskeleton robot is verified with reference to manipulability variation of kinematic model of human lower arm. The performance of passive DoF of the upper limb exoskeleton robot with respect to improve the pHRI by means of flexible bellow coupling is investigated in this paper.

D1S1-2.3 8:30 ***A Study on Self-Balancing Electric Motorcycles with Two-Wheel Steering*** *44*

Chuan Yang and Toshiyuki Murakami (Keio University, Japan)

Due to their good portability and flexibility, two-wheel electric motorcycles are popular in many countries nowadays. However, keeping the motorcycles balanced, which is a valuable research in an accelerating ageing society, has not been thoroughly researched. In this essay, a novel self-balancing electric motorcycle is put forward to cover this deficiency. By controlling the two-wheel steering, in this paper, the balance of the electric motorcycle can be kept with its wheels swinging. Also, three different kinds of structures of the two-wheel steering motorcycles were discussed. And a master operator is added for the drivers, even the aged drivers to drive the motorcycle at ease. Such balance can be kept when the motorcycle is parked as well. The feasibility was proved by preliminary experiments.

D1S1-2.4 8:45 ***Performance Evaluation of a Three Dimensional Laser Scanner for Industrial Applications*** 50

Prasad Manorathna (EPSRC Centre for Innovative Manufacturing in Intelligent Automation, Loughborough University, United Kingdom)

Laser scanners are nowadays extensively used in industries due to their high accuracy, resolution and robustness. However, the specifications provided with most laser scanners are debatable and without proper analysis the output results from the scanners cannot be trusted. The performance of laser based scanners depends on many aspects including ambient lighting condition, surface reflectivity, surface roughness and stand-off distance. In this paper a set of performance evaluation tests for a three dimensional (3D) laser scanner is presented. An initial definition of the best strategy for testing prior to its use is proposed. The performance of the scanner was evaluated under different operating conditions such as different surface reflectivity, viewing angle, surface roughness and stand-off distance. The optimum working range of the laser scanner was established and the regions where the laser scanner produces inappropriate data was identified and quantified. A similar testing approach can be used for any industrial laser scanner prior to its application to minimize any unambiguity in measurements.

D1S1-2.5 9:00 ***Position Based Static Friction Estimation for DC Motors Using Disturbance Observer*** 56

Mahawaththe Kodithuwakkuge Chathuranga Dinesh Chinthaka (University of Moratuwa, Sri Lanka)

Friction is often neglected in DC servomotor applications. It is valid if the servo motor is small and the frictional torque elements are small when compared to the torque. Fixed friction and viscous friction are the main constituents of the friction. For precise motor control applications, friction could not be neglected. In many applications, researchers have attempted to estimate an average for a whole rotation. However even these estimation values are not valid for applications when it is having rotor wide frictional distribution. This research attempts to estimate the friction around 3600 degrees of rotation. Disturbance Observer is used as the torque measurement tool. Results show the estimated frictional values using the proposed method.

D1S1-3: Solid State Drives and Control

Room: Vip Lounge

Chairs: A. G. Buddhika P. Jayasekara (University of Moratuwa, Sri Lanka), Chandima Dedduwa Pathirana (University of Moratuwa, Sri Lanka)

D1S1-3.1 8:00 ***Development of a Field Programmable GATE Array Based Computer to Controller Area Network Store and Forward Buffer*** 62

Neranjaka Jayarathne (General Sir John Kotelawala Defence University, Sri Lanka); Kithsiri Jayananda (Faculty of Science, University of Colombo, Sri Lanka)

In this paper the development of a Field programmable Gate Array (FPGA) based general purpose computer to Controller Area Network (CAN) store and forward buffer is being discussed. This buffer will read from the incoming data from the computer as bytes and collect and combine them to form the CAN frame and post it to the CAN network for transmission. In the process of development, CAN message frame architecture, voltage levels and bit coding principles were studied extensively. For the experiments and implementation of the designed buffer a developer board with Xilinx Spartan 3E FPGA which has 1920 Configurable Logic Blocks (CLB) was used. Computer to FPGA communications is carried out using RS-232 serial communications. 136 bit long CAN frame is built on the computer and separated to 17 bytes and forwarded to the FPGA. The FPGA assembles it and posts the frame to the network. In this implementation, from the available total, 315 flip flops and 569 look up tables (LUT) were used. From these 443 were used as logic, 126 were used as route through and 1 was used as a shift register. Since the usage of the RS-232 protocol the communication bottleneck due to this makes rise to a delay of 14.1667 ms per frame sent from computer to the FPGA. This delay can be reduced by using Universal Serial Bus (USB) protocols to communicate with the computer.

D1S1-3.2 8:15 ***A Novel Controller for a Voltage Source Sine Wave Transformerless Boost Inverter*** *68*

Devinda Molligoda (University of Moratuwa & GSI Application Development Center, Sri Lanka); Rohan Munasinghe (University of Moratuwa & Faculty of Engineering, Sri Lanka)

In this paper a transformerless voltage source sine wave inverter is proposed. A previously developed tri-state boost converter is utilized for the stepping up operation. In this topology the dynamic response of the inverter is increased, by avoiding the right hand plane zero in the converter's small-signal control-to-output transfer function when operating in the continuous conduction mode. The reference voltage for the tri-state boost converter is determined from the measured output voltage of the sine wave inverter and the calculated instantaneous value of the sine wave. The inverter with the tri-state boost converter and the inverter with a classical boost converter with voltage mode control and current mode control are compared for the dynamic response and efficiency. The analytical work of the design has been verified using a simulation. Furthermore, the boost converter is implemented in hardware to verify the boost inverter calculations. The current mode control and the tri-state logic hardware implementation are ongoing, and it is presented as future work. Finally, two user selectable modes are proposed for the inverter optimized for dynamic performance or efficiency.

D1S1-3.3 8:30 ***Multiphase Induction Motor Drive with 1:3:9:15 Speed Ratios for Gear Free Electric Vehicle Application*** *74*

Umesh B s (Indian Institute of Technology Hyderbad, India); Siva Kumar K (Iit Hyderabad, India)

Wide variation in speed from low speed crawling to high speed cruising, maintaining constant power operation is the most desired characteristic of a drive used in electric vehicles (EV). Pole phase modulated multiphase induction motor (IM) drive is capable of extending the constant power operation over very wide range of speed with transient high torque for electric launch or hill climbing. In this paper a 45 phase squirrel cage IM drive with 1:3:9:15 speed ratio using pole phase modulation is proposed. The four speeds achieved by electrical pole changing eliminate the need of mechanical gear box which saves in weight and size of the EV. Phase number appears to be slightly large, but with the advantages such as reduction in voltage rating of the power switch and dc link supports the selection of large phase number. In addition high number of phases considerably reduces torque ripple and increases efficiency by reducing slot harmonics. operation of the proposed IM drive for 45 phase 2 pole, 15 phase 6pole, 5 phase 18 pole and 3 phase 30 pole combinations is verified by FEA simulation using 5hp model in ansys Maxwell (an electromagnetic package) and simplorer (associated circuit simulator). Drive performance with pure sinusoidal voltage and two-level inverter excitation are compared. Due to the selection of high number of phases even with two-level inverter excitation, performance of the drive is not degraded.

D1S1-3.4 8:45 ***High Gain Step Up DC-DC Converter for DC Micro-Grid Application*** *80*

Manoranjan Sahoo (IIT Hyderabad, India); Siva Kumar K (Iit Hyderabad, India)

In this paper a very high gain step up DC-DC converter is proposed. Maximum voltage gain in conventional boost converter like, switched inductor converter, switched capacitor converter, cascaded boost converter etc. are limited due to extreme duty cycle (i.e. duty cycle near to unity). Operation at extreme duty cycle leads to, serious reverse recovery problem at the switches, high conduction losses, high electromagnetic interference etc. Isolated converter such as fly-back converter, push-pull converter, forward converter, bridge converters etc. overcomes the above issues, where basically a transformer or coupled inductor is used to boost the voltage. But, inclusion of transformer or coupled inductor introduces voltage spike at the main switch and power loss due to leakage inductance. Recently, DC micro-grid gets major importance because of the significant increase in DC loads and demand of high quality power. These DC loads require different voltage levels based on their power ratings. Photo voltaic source (PV) is one of the prime source of energy in DC micro-grid. A very high voltage gain converter is necessary for DC micro-grid because of low PV source voltage. In this regard, here a step up DC-DC converter is proposed, which possess a very high voltage gain characteristic. Along with this, it provides the additional advantage of supplying power to two different loads (i.e. one for high voltage level and another for low voltage level), which makes it more suitable for DC micro-grid application. Steady state analysis and PWM control of the proposed converter are described in this paper. Theoretical verification of the proposed converter has been done by simulating it in MATLAB Simulink.

D1S1-3.5 9:00 ***Effective Current Harmonics Mitigation At Point of Common Coupling Using Multilevel Active Front End Converter*** *85*

Praveen Amarajeewa, Pasan Gunawardana, Chathuri Harshani, Sanjeewa Madurawala and Chandima Dedduwa Pathirana (University of Moratuwa, Sri Lanka)

An operational analysis of a multilevel active front end rectifier, which has the mitigating capability of the current harmonics generated by the nonlinear loads connected to the same power distribution bus would be presented in this paper. Undesirable conditions in the power network such as voltage unbalances and spikes can affect negatively on the operation of very sensitive electric devices. Thus decreasing the Total Harmonic Distortion (THD) of the line current at the Point of Common Coupling (PCC) of the utility was the main objective. The control strategy allows the multilevel converter to operate as a rectifier and an active power filter simultaneously. The active front-end rectifier acts directly on the mains line current and forces it to be sinusoidal and in phase with the mains voltage supply.

9:30 AM - 10:30 AM

D1-Keynote: Keynote on Energy, The Grid and Receding Horizon Optimal Control

Prof. Iven Mareels
Room: Bougainvillea Ballroom
Chair: Saman Halgamuge (The University of Melbourne, Australia)

From a sustainability point of view the electrification of transport, in particular when electrical energy could be supplied from purely renewable primary sources, seems a very logical way forward. We briefly consider the world scale implications of such a convergence, observing its technical feasibility but also noting the sine qua non condition: a need for global world scale international collaboration. Indeed many nations simply do not have the renewable energy resource in their own right, but the collective, the planet, does. By necessity (as we are not in a position to solve world peace) this talk will concentrate on the transition that needs to occur in the electricity grid in order to manage the electrification of transport, and more particularly consider the control/management issues involved in the "new" grid. The "new" grid will need to expand in size, and at the same time pay management will need more attention to the last mile in the grid. The utility in grid assets which is poor in general will also need to improve, in order to make the new grid economically palatable. The control issue in all of this, is one of matching energy needs whilst shaping both energy supply and energy demand, making full use of both embedded generation capacity as well as distant base load supply, whilst maximising the utility of the grid. A particular instance of this problem is posed in this talk, in particular concentrating on the last mile of the grid. The latter, the low voltage end of the grid, is by and large neglected in the present incarnation of the grid. As a consequence embedded energy sources and the inherent energy storage (which we discuss) are poorly treated. We argue that the present grid design paradigm of power supply follows power demand has to be abandoned, and provide a way of doing this using a novel-to-the-grid control approach, where power demand is shaped to accommodate available power supply but such that energy needs are met. By way of example we study the impact of electrical vehicles on the grid in Victoria, Australia. To this end, we revisit the modeling and control of a low voltage distribution network, and in particular pose the problem of electric vehicle charging as a receding horizon control problem for a spatially distributed collection of cars, subject to the network's operational limits. Realistic models, validated against operational data (for local networks in Australia) will be presented. Our modelling tool, called POSSIM, is open software, maintained by our team, see http://www.possim.org/. In this context, we discuss the potential for adaptive model identification, centralised control options as well as decentralised and consensus based control options. Some early results on the potential penetration of electric vehicles in a managed smart grid environment are also presented. Acknowledgements The work as discussed is based on an Australian Research Council sponsored project "Integrating Electric Vehicles into a Smart Grid" at the University of Melbourne, School of Engineering, executed by Prof Iven Mareels, Prof Doreen Thomas, A/Prof Marcus Brazil, Dr Tansu Alpcan, Dr Julian de Hoog and PhD students Valentin Muenzel, Lu Xia, Derek Jayasuriya and Ramachandra Rao Kolluri. The project involves collaboration with IBM's Smart Grid efforts around the nPlug idea introduced by Dr Shivkumar Kalyanaraman, a variant of which will be briefly discussed in this talk; as well as collaboration with NICTA's Smart Grid Initiative, with Prof Rob Evans and A/Prof M. Aldeen.

10:30 AM - 10:45 AM

D1-Tea Break-1: Tea Break

10:45 AM - 11:30 AM

D1-Plenary: Plenary speech on Time-Delay Systems - Problems, Solutions and Applications

Professor Kenji Natori
Room: Bougainvillea Ballroom
Chair: A. M. Harsha S. Abeykoon (University of Moratuwa, Sri Lanka)

Abstract: Time delay in control systems has been one of challenging problems in the field of control engineering. It has been studied in various fields, like chemical process, large-scale systems, telerobotics, and so on. Now that networked control system (NCS) that implements control system through shared networks is being developed rapidly and widely, control of time-delay systems is drawing further attention. In this talk, first, fundamental characteristics of time-delay systems are briefly introduced. Characteristic properties of time-delay element in control systems, and performance deterioration and instability caused by time delay in control systems are covered. Then, principle and validity of a time-delay compensation method based on network disturbance (ND) concept and communication disturbance observer (CDOB) that author has studied for about 10 years are described. Finally, this talk presents application of the time-delay compensation method to bilateral teleoperation systems for haptics.

10:45 ***Analysis on Bilateral Control System with Time Delay Based on Mechanical Power Factor as Performance Index (Invited Paper)*** *91*

Kenji Natori (Chiba University, Japan)

This paper presents analysis of bilateral control system with time delay based on mechanical power factor (MPF) concept. MPF is an interesting and useful performance index for online evaluation of bilateral control systems by using experimental or simulation data. First, effect of time delay and the effectiveness of a time-delay compensation method by using communication disturbance observer (CDOB) are studied based on MPF. Then, effects of controller gains on the performance of the bilateral control systems are studied. The obtained analysis result will be a useful guideline for design of bilateral control systems with time delay.

11:30 AM - 12:30 PM

D1S2-1: Intelligent Machines and Man-machine Co-existence

Room: Salon Jasmine

Chairs: Rohan Munasinghe (University of Moratuwa, Sri Lanka), Upeka Premaratne (University of Moratuwa, Sri Lanka)

D1S2-1.1 11:30 ***Action Recognition Using a Spatio-Temporal Model in Dynamic Scenes*** *97*

K. G. Manosha Chathuramali and Ranga Rodrigo (University of Moratuwa, Sri Lanka)

Action Recognition in a video plays an important role in computer vision and finds many applications in areas such as surveillance, sports, and elderly monitoring. Existing methods mostly rely on stationary backgrounds. Actions recognition in dynamic backgrounds typically requires standard preprocessing steps such as motion compensation, background modeling, moving object detection and object recognition. The errors of the motion compensation step and background modelling increase the mis-detections. Therefore action recognition in dynamic background is challenging. In this paper, we use a combination of pose characterized by a silhouette and optic flows synthesized into a histogram. This enables us to classify the movement of the actor versus movement of the background. We use four background models to extract the silhouette from the frame. We use SVM to recognize actions, according to several evaluation protocols. We perform several experiments and compare over a diverse set of challenging videos, including the new Change Detection Challenge Dataset. Our results perform better than existing methods.

D1S2-1.2 11:45 ***Abnormal Activity Recognition Using Spatio-Temporal Features*** *103*

K. G. Manosha Chathuramali, Ranga Rodrigo and Sameera Ramasinghe (University of Moratuwa, Sri Lanka)

Abnormal activity detection plays an important role in many areas such as surveillance, military installations, and sports. Existing abnormal activity detectors mostly rely on motion data obtained over a number of frames to characterize abnormality. However, only motion may not be able to capture all forms of abnormality, in particular, poses that do not amount to motion "outliers". In this paper, we propose two different spatiotemporal descriptors, silhouette and optic flow based method and dense trajectory based method which additionally include trajectory shape descriptor, to detect abnormalities. These two descriptors enable us to classify abnormal versus non-abnormal activities using SVM. Comparison with existing methods, using five standard datasets, shows that dense trajectory based method outperforms state-of-the-art results in crowd dataset and silhouette and optic flow based method outperforms in some datasets.

D1S2-1.3 12:00 ***Plagiarism Detection on Electronic Text Based Assignments Using Vector Space Model*** *108*

Jiffriya Cader (University of Peradeniya, Sri Lanka); Akmal Jahan (University of Peradeniya & South Eastern University of Sri Lanka, Sri Lanka); Roshan G. Ragel (University of Peradeniya & University of New South Wales, Sri Lanka)

Plagiarism is known as illegal use of others' part of work or whole work as one's own in any field such as art, poetry, literature, cinema, research and other creative forms of study. Plagiarism is one of the important issues in academic and research fields and giving more concern in academic systems. The situation is even worse with the availability of ample resources on the web. This paper focuses on an effective plagiarism detection tool on identifying suitable intra-corpal plagiarism detection for text based assignments by comparing unigram, bigram, trigram of vector space model with cosine similarity measure. Manually evaluated, labelled data set was tested using unigram, bigram and trigram vector. Even though trigram vector consumes comparatively more time, it shows better results with the labelled data. In addition, the selected trigram vector space model with cosine similarity measure is compared with tri-gram sequence matching technique with Jaccard measure. In the results, cosine similarity score shows slightly higher values than the other. Because it focuses on giving more weight for terms that do not frequently exist in the dataset and cosine similarity measure using trigram technique is more preferable than the other. Therefore, we present our new tool and it could be used as an effective tool to evaluate text based electronic assignments and minimize the plagiarism among students.

D1S2-1.4 12:15 ***Recognition of Badminton Strokes Using Dense Trajectories*** *113*

Sameera Ramasinghe, K. G. Manosha Chathuramali and Ranga Rodrigo
(University of Moratuwa, Sri Lanka)

Automatic stroke recognition of badminton video footages plays an important role in the process of analyzing players and building up statistics. Yet recognizing activities from broadcast videos is a challenging task due to person dependant body postures and blurring of the fast moving body parts. We propose a robust and an accurate approach for badminton stroke recognition using dense trajectories and trajectory aligned HOG features which are calculated inside local bounding boxes around players. A four-class SVM classifier is then used to classify badminton strokes to be either smash, forehand, backhand or other. This approach is robust to noisy backgrounds and provides accurate results for low resolution broadcast videos. Our experiments also reveal that this approach needs relatively fewer training samples for accurate recognition of strokes compared to existing approaches.

D1S2-2: Robotics, Automation and Control

Room: Orchid
Chairs: Kenta Seki (Nagoya Institute of Technology, Japan), A. M. Harsha S. Abeykoon (University of Moratuwa, Sri Lanka)

D1S2-2.1 11:30 ***Formation Control of Multiple Mobile Robots Based on the Modal Decomposition by Discrete Fourier Series Expansion*** *119*

Masaki Wada and Tomoyuki Shimono (Yokohama National University, Japan)

This paper proposes a formation control method of multiple mobile robots based on the modal decomposition by Discrete Fourier Series expansion (DFS). The proposed method controls the formation by controlling the linear velocity and rotational velocity in modal space. In addition, a command velocity can be independently designed and combined in each decomposed mode. Finally, the validity of the proposed method is confirmed by the experimental results.

D1S2-2.2 11:45 ***Modal Multirate Control for Scaled Bilateral System Taking Relative Velocity Resolution Into Account*** *125*

Shuang Xu and Tomoyuki Shimono (Yokohama National University, Japan)

Macro-Micro bilateral manipulation is a remote control with scaling factor of position/force between master (macro) and slave (micro) system. Normally, bilateral control can realize not only high performance of force transmission because of the utilization of reaction force observer (RFOB), but also accurate tracking of position because of disturbance observer (DOB). Therefore, because of the implement of scaling factor, the spatial modal loses the balance of bilateral control between master and slave system, which makes the performance of bilateral system deteriorated. This paper proposes a multirate and different time resolution controller for scaled bilateral system, which can realize high performance of position tracking and force transmission. In this paper, experiments are given by 2 linear motors as master and slave system respectively, with both of free motion and contacted motion. The master motor is manipulated by human hand. The Fast Fourier Transform (FFT) analysis of estimated disturbance force by DOB is given to confirm the effectiveness of proposed controller.

D1S2-2.3 12:00 ***DC Motor Inertia Estimation for Robust Bilateral Control*** *131*

G V A G Asanka Perera (University of Moratuwa, Sri Lanka); Branesh Madhavan Pillai (Mahidol University, Thailand); A. M. Harsha S. Abeykoon (University of Moratuwa, Sri Lanka)

Identification of system parameters of a small DC motor is a complex and challenging task. This research proposes a disturbance observer (DOB) based novel Change of Inertia Observer (CIOB) to estimate the moment of inertia of a DC motor. Moment of inertia of a small DC motor is estimated using CIOB based velocity test and reaction torque observer (RTOB) based inverse motion acceleration test, and the results are compared with conventional acceleration and deceleration motion tests. These two conventional tests are more suitable for large DC motors and less accurate for small DC motors. DOB is used to estimate the disturbance torques and CIOB is to find the change of inertia. Estimated moments of inertia values using the proposed methods are compared with the conventional methods by applying the values to a bilateral teleoperation system. Proposed methods have produced better results than in the conventional methods. Proposed CIOB method of inertia estimation is much simpler and easier to use compared to conventional methods.

D1S2-3: Sustainable Power and Energy Systems

Room: Vip Lounge

Chairs: Visvakumar Aravinthan (Wichita State University, USA), Chandima Dedduwa Pathirana (University of Moratuwa, Sri Lanka)

D1S2-3.1 11:30 ***A Load Flow Algorithm for Radial Systems Having Renewable Energy Generation Sources*** *138*

James Ranjith Kumar and Amit Jain (CPRI, India)

In this paper, an algorithm for obtaining load flow solutions for radial systems having generation based on renewable energy have been presented. These renewable distributed generations (DG) in the radial distribution system are modeled as active power and voltage magnitude specified buses (PV) and complex power specified buses (PQ). This method uses an improved backward forward sweep method where the line flows are considered and a solution based on quadratic equation is employed. For handling PV buses, a direct solution based technique is used for computing the reactive power injection to maintain the specified voltage magnitude. Thus by exploiting the radial nature of distribution systems even though generation is present, the overall convergence is improved. The proposed method has been tested with two radial systems and its results are validated.

D1S2-3.2 11:45 ***Electric Vehicle Charging Management Using Discrete Event Dynamic Systems*** *143*

Saeed Alsaleeb, Visvakumar Aravinthan and Edwin Sawan (Wichita State University, USA)

Management of Electric Vehicle charging has gained significant interest mainly due its impacts on the distribution systems. Several control strategies which are proposed in the literature consider electric vehicle charging as time based signals on the system. This work proposes an alternative method by considering the charging as dynamic events on the distribution system. Proposed multi-state semi control and full control models are based on the ability to charge the vehicles at different rates and the ability to move from one state to another. Finally, a dynamic full control model based on the distribution system conditions is proposed. The proposed model has the potential to manage the load on the distribution transformer to sustain its life with this new type of load.

D1S2-3.3 12:00 ***Radial Feeder Reliability Evaluation in the Presence of Battery Storage Using Modified Sequential Monte Carlo Simulation*** *149*

Avinash Banajiger and Visvakumar Aravinthan (Wichita State University, USA)

Smart Grid initiative requires improvements to distribution system operation. One of the improvements is to use battery storage to support the distribution system. These batteries have the ability to improve the system reliability. This work develops a simulation based reliability evaluation technique with detailed battery operation model. The state of charge of battery, loss of capacity over age and the limited battery capacity are used in the battery operation model. To incorporate the effect of one element on the failure of a component downstream to it modified Time Sequential Monte Carlo (TSMC) is proposed in this work. The first part of this work proposes the modified TSMC and tests its usability using a feeder from Roy Billinton Test System (RBTS) and the results are compared with the analytical and Time Sequential Monte Carlo Technique. The second part of the work evaluates the reliability indices of a simple feeder in the presence of battery storage.

D1S2-3.4 12:15 ***Impacts of FACTS Device on Wind Farm Protection: Comparison Between STATCOM and UPFC*** *155*

Suman Gautam and Chengzong Pang (Wichita State University, USA); Lin Yang (North China Electric Power University, P.R. China)

With the increasing trend of wind energy in the power system, the significant impacts for system operation are got more attentions. Due to voltage fluctuating supplied by the renewable sources, it is a significant challenge to maintain power quality in power system with existing technologies. Voltage fluctuating will cause the balance problems for power flow among wind power plants and eventually will affect the associated protection systems. This paper will discuss the impacts on protection system due to integrating the renewable energy resources into grid, especially with widely used Flexible Alternating Current Transmission Systems (FACTS) devices. Two major categories for FACTS, Static Synchronous Compensator (STATCOM), and Unified Power Flow Controller (UPFC), will be studied and compared for their impacts on wind farm protection systems. Simulation results will be presented, which show that the relay system has different response for STATCOM and UPFC, which UPFC response much faster than STATCOM while maintaining the power system steady state stability.

12:30 PM - 1:15 PM

D1-Lunch: Lunch

1:30 PM - 3:00 PM

D1S3-1: Intelligent Machines and Man-machine Co-existence

Room: Salon Jasmine
Chairs: Pubudu Pathirana (Deakin University, Australia), Pradeepa Samarasinghe (SLIIT, Sri Lanka)

D1S3-1.1 1:30 ***A Structured Hardware Software Architecture for Peptide Based Diagnosis - Sub-string Matching Problem with Limited Tolerance*** *161*

Sugandima Vidanagamachchi and Shirley Devapriya Dewasurendra (University of Peradeniya, Sri Lanka); Roshan G. Ragel (University of Peradeniya & University of New South Wales, Sri Lanka); Mahesan Niranjan (University of Southampton, United Kingdom)

The problem of inferring proteins from complex peptide cocktails (digestion products of biological samples) in shotgun proteomic workflow sets extreme demands on computational resources in respect of the required very high processing throughputs, rapid processing rates and reliability of results. This is exacerbated by the fact that, in general, a given protein cannot be defined by a fixed sequence of amino acids due to the existence of splice variants and isoforms of that protein. Therefore, the problem of protein inference could be considered as one of identifying sequences of amino acids with some limited tolerance. Two problems arise from this: a) due to these (permitted) variations, the applicability of exact string matching methodologies could be questioned and b) the difficulty of defining a reference (peptide/amino acid) sequence for a particular set of proteins that are functionally indistinguishable, but with some variation in features. In this paper, we present a model-based hardware acceleration of a structured and practical inference approach that we have developed and validated to solve the inference problem in a mass spectrometry experiment of realistic size. Our approach starts from an examination of the known set of splice variants and isoforms of a target protein to identify the Greatest Common Stable Substring (GCSS) of amino acids and the Substrings Subjects to Limited Variation (SSLV) and their respective locations on the GCSS. We hypothesise that these latter substrings (SSLV) appear inside complete peptides and not cutting across peptide boundaries. Then we define and solve the Sub-string Matching Problem with Limited Tolerance (SMPLT) using the Bit-Split AhoCorasick Algorithm with Limited Tolerance (BSACLT) that we define and automate. We validate our approach on identified peptides in a labelled and clustered data set from UNIPROT. We accelerate the computational workflow of protein inference described above using a model-based hardware software co-design strategy. Identification of Baylisascaris Procyonis infection was used as an application instance. This workflow can be generalised to any inexact multiple pattern matching application by replacing the patterns in a clustered and distributed environment which permits a distance between member strings to account for permitted deviations such as substitutions, insertions and deletions. We have achieved 10 times maximum speed-up in the co-designed workflow compared to a similar workflow purely run on the processor used for co-design.

D1S3-1.2 1:45 ***A Fuzzy Integrated Self-tuning PID Technique for Mini Robot*** *167*

Gayan Brahmanage and G V A G Asanka Perera (University of Moratuwa, Sri Lanka)

This paper presents the modeling, numerical simulation, control and the testing of a fuzzy integrated selftuning PID controller for a line following mini robot. The system is modeled for different lighting conditions considering the desired and ambient light intensities. The system modeling is performed in a simulation environment and the generated control parameters are applied to the tuned fuzzy controller. The proposed controller architecture is extended to achieve smooth and fast movements of the robot under varying ambient and surface conditions. This extension of the fuzzy based PID controller can be applied to similar applications which deal with high degrees of environmental lighting changes. The tuned system is capable of self-tune the PID parameters without human interaction. The proposed design shows a significantly improved performance over its conventional counterpart.

D1S3-1.3 2:00 ***A Deterministic and Robust Wireless Control System for Driving a Six Wheeled All-Terrain Vehicle*** *174*

Shreyas Kulkarni (College of Engineering, Pune, India); Sarang Junghare (College Of Engineering Pune, India); Siddharth Banerjee (College of Engineering, Pune, India); Ashok Sapkal (Pune University, India)

This paper describes the robotic control system implemented to handle tasks, which if performed by humans pose significant risks. The system described is used for controlling a six wheel all-terrain vehicle through a radio interface from a safe distance. Dual wireless video channels offer a feedback to the operator for maneuvering and controlling the robot. Developing robotic manipulators and vehicles for real time systems require enhanced and deterministic control of peripherals. Functional state machine diagrams that have been developed for this application showcase the predictable behavior of the robot and if necessary, can be further extended to incorporate additional tasks. Special care has been taken to keep the system compact and minimize the overhead from the timing requirements of control system software so that it can be deployed on a low cost and low power platform. Highly efficient H-bridge drivers for controlling high torque motors have been specially controlled through slow decay PWM control strategy for reducing dissipated heat. The physical implementation ensures optimum performance from all components of the system precluding EMI/EMC and power supply related issues. Field trials have yielded promising results proving that such a control system can be suitably modified to cater to the needs of unmanned ground vehicle applications like remote surveillance, bomb disposal, etc.

D1S3-1.4 2:15 ***LineCAPTCHA Mobile: A User Friendly Replacement for Unfriendly Reverse Turing Tests in Mobile Devices*** *180*

Chaminda Bulumulla (University of Peradeniya, Sri Lanka); Roshan G. Ragel (University of Peradeniya & University of New South Wales, Sri Lanka)

As smart phones and tablets are becoming ubiquitous and taking over as the primary choice for accessing the Internet worldwide, ensuring a secure gateway to the servers serving such devices become essential. CAPTCHAs play an important role in identifying human users in internet to prevent unauthorized bot attacks. Even though there are numerous CAPTCHA alternatives available today, there are certain drawbacks attached with each alternative, making them harder to find a general solution for the necessity of a CAPTCHA mechanism. With the advancing technology and expertise in areas such as AI, cryptography and image processing, it has come to a stage where the chase between making and breaking CAPTCHAs are even now. This has led the humans with a hard time deciphering the CAPTCHA mechanisms. In this paper, we adapt a novel CAPTCHA mechanism named as LineCAPTCHA to mobile devices. LineCAPTCHA is a new reverse Turing test based on drawing on top of Bezier curves within noisy backgrounds. The major objective of this paper is to report the implementation and evaluation of LineCAPTCHA on a mobile platform. At the same time we impose certain security standards and security aspects for establishing LineCAPTCHAs which are obtained through extensive measures. Independency from factors such as the fluency in English language, age and easily understandable nature of it inclines the usability of LineCAPTCHA. We believe that such independency will favour the main target of LineCAPTCHA, user friendliness and usability.

D1S3-1.5 2:30 ***Automatic Anemia Identification Through Morphological Image Processing*** *186*

Sanjeevi Sashikala Chandrasiri (Sri Lanka Institute of Information Technology, Sri Lanka); Pradeepa Samarasinghe (SLIIT, Sri Lanka)

Though blood Cell manipulation has been an interesting research area for many years, most of the techniques presented in literature produce poor segmentation results for images with high overlapped blood cells. In this paper, we introduce a fully automatic low cost and accurate system to identify four common types of anemia and report on blood cell count. The results of our system indicate a good impact with the manually processed results of 99.678% accuracy of Red Blood Cell count. The diagnosis of Elliptocytes, Microcytes, Macrocyte and Spherocytes anemia result in the range of 91%-97% accuracy.

D1S3-2: Robotics, Automation and Control

Room: Orchid

Chairs: Kenji Natori (Chiba University, Japan), R. A. Ruwan Chandra Gopura (University of Moratuwa, Sri Lanka)

D1S3-2.1 1:30 ***An Adaptive Complementary Filter for Inertial Sensor Based Data Fusion to Track Upper Body Motion*** *191*

Sajeewani M. Karunarathne (Sabaragamuwa University of Sri Lanka, Sri Lanka); Samitha W Ekanayake and Pubudu Pathirana (Deakin University, Australia)

Remote human activity monitoring is critical and essential in physiotheraphy with respect to the skyrocketing healthcare expenditure and the fast aging population. One of frequently used method to monitor human activity is wearing inertial sensors since it is low-cost and accurate. However, the measurements of those sensors are able only to estimate the orientation and rotation angles with respect to actual movement angles, because of differences in the body's co-ordination system and the sensor's co-ordination system. There were numerous studies being conducted to improve the accuracy of estimation, though there is potential for further discussions on improving accuracy by replacing heavy algorithms to less complexity. This research is an attempt to propose an adaptive complementary filter for identifying human upper arm movements. Further, this article discusses a feasibility of upper arm rehabilitation using the proposed adaptive complementary filter and inertial measurement sensors. The proposed algorithm is tested with four healthy subjects wearing an inertial sensor against gold standard, which is the VICON system. It demonstrated root mean squared error of 8:77 for upper body limb orientation estimation when compared to gold standard VICON optical motion capture system.

D1S3-2.2 1:45 ***Control of a Biped Robot with Flexible Foot on an Uneven Terrain*** *196*

Sreeja Balakrishnan (Amrita Vishwa Vidyapeetham, India); Shikha Tripathi (Amrita School of Engineering, Amrita Vishwa Vidhyapeetham, India); Sudarshan Tsb (Amrita Vishwa Vidyapeetham University & School of Engineering, India)

A technique to achieve stable walking of a biped robot on an uneven terrain is proposed in this paper. A biped structure with a flexible foot will be able to navigate uneven terrain more effectively than the same with a flat foot. The criterion used for stable walking is Zero moment point (ZMP). The geometric center of the support polygon formed by the flexible foot is taken for dynamically planning the reference trajectory at every step. A control law is derived using computed torque control and its validity is checked using simulation study. It is observed that the actual trajectory closely follows reference with the proposed control law.

D1S3-2.3 2:00 ***Bilateral Control of a Half-circle-shaped Tubular Linear Motor with Disturbance Model Based on Trigonometric Function of Two Variables*** *202*

Hiroshi Asai, Mototsugu Omura, Tomoyuki Shimono and Yasutaka Fujimoto (Yokohama National University, Japan)

In robotic surgery without contact force transmission characteristic between master and slave system, the risk of a medical mistake becomes high. Then, a novel surgical assistance robot with force transmission is expected to be developed. This paper firstly introduces a two-degree-of-freedom (2-DOF) haptic system which can realize pitching motion and yawing motion. The system is composed of four half-circle-shaped tubular linear motors. Then, this paper focuses on the pitching motion system of the 2-DOF system. In this system, the effect of gravity and friction force is changed by the position and the velocity of motor. This paper proposes a disturbance model based on a trigonometric function of position and velocity for this system. It realizes vivid force transmission between master and slave motor in bilateral control. Bilateral control test of this system with disturbance model is performed. Experimental results are presented to validate the proposed model.

D1S3-3: Information and Communication Technology

Room: Vip Lounge

Chairs: Ruwini Edirisinghe (RMIT Univerity, Australia), Amirthalingam Ramanan (University of Jaffna, Sri Lanka)

D1S3-3.4 2:15 ***Efficient Switch Architectures for Pre-configured Backup Protection with Sharing in Elastic Optical Networks*** *237*

Suthaharan Satkunarajah and Krishanthmohan Ratnam (University of Peradeniya, Sri Lanka); Roshan G. Ragel (University of Peradeniya & University of New South Wales, Sri Lanka)

In this paper, we address the problem of providing survivability in elastic optical networks (EONs). EONs use fine granular frequency slots or flexible grids, when compared to the conventional fixed grid networks and therefore utilize the frequency spectrum efficiently. For providing survivability in EONs, we consider a recently proposed survivability method for conventional fixed grid networks, known as pre-configured backup protection with sharing (PBPS), because of its benefits over the traditional survivability approaches such as dedicated and shared protection. In PBPS, backup paths can be pre-configured and at the same time they can share resources. Therefore, both short recovery time and efficient resource usage can be achieved. We find that the existing switch architectures do not support both PBPS and EONs. Specifically, we identify and illustrate that, if a switch architecture is not carefully designed, several key problems/issues might arise in certain scenarios. Such problems include unnecessary resource consumption, inability of using existing free resources, and incapability of sharing backup paths. These problems appear when PBPS is adopted in EONs and they do not arise in fixed grid networks. In this paper, we propose new switch architectures which support both PBPS and EONs. Particularly, we illustrate that, our switch architectures avoid the specific problems/issues mentioned above. Therefore, our switch architectures support using resources more efficiently and reducing blocking of requests.

3:00 PM - 4:30 PM

D1S4-1: Intelligent Machines and Man-machine Co-existence

Room: Salon Jasmine

Chairs: Shirley Devapriya Dewasurendra (University of Peradeniya, Sri Lanka), Thilina Lalitharatne (University of Moratuwa, Sri Lanka)

D1S4-1.1 3:00 ***Perturbing Effect Compensation Technique for Smart Sensors*** *244*

Anuradha Chathuranga Ranasinghe (University of Turku & Sri Lanka Institute of Information Technology, Sri Lanka); Lahiru Kasun Rasnayake (University of Turku, Finland); Abhinav Sinha (TATA Consultancy Services Limited, India); Kavinda Keshan Rasnayake (University of Colombo, Sri Lanka)

Environment monitoring systems of today need to be robust and accurate owing to the unpredictability of possible deployment scenarios. So, external disturbances on the sensor should be taken into account in such cases. This paper presents an automatic calibration technique for industrial sensors based on rational interpolation where the system itself determines the transfer function of the sensor's characteristics through point by point calibration. The properties of rational functions make it ideal to model a sensor's transfer function to match its non linear characteristics. Further the proposed method can be extended into 2 dimensional calibrations where the system will evaluate the sensor behavior with a secondary effect and minimize ideality errors. In the later stage, the implementation of the algorithm on a low cost embedded environment has been also presented in this paper. Theoretical and practical results were evaluated for different type of sensors proving its general applicability.

D1S4-2: Sustainable Power and Energy Systems

Room: Orchid
Chairs: Nilakshi Lidula (University of Moratuwa, Sri Lanka), Anura Wijayapala (University of Moratuwa, Sri Lanka)

D1S4-2.1 3:00 ***Micro Inverter with a Front-end Current-Fed Converter*** *272*

Dulika Rukshan Nayanasiri and Gilbert Foo (Nanyang Technological University, Singapore); Mahinda Vilathgamuwa (Queensland University of Technology, Australia); Douglas Maskell (Nanyang Technological University, Singapore)

The reliability of micro inverters is an important factor as it would be necessary to reduce cost and maintenance of the small and medium scale distributed PV power conversion systems. Electrolytic capacitors and active power decouple circuits can be avoided in micro inverters with the use of a medium voltage DC-link. Such a DC-link based micro inverter is proposed with a front-end dual inductor current-fed push-pull converter. The primary side power switches of the front-end converter have reduced switching losses due to multi-resonant operation. In addition, the voltage and current stresses on the diodes of the secondary diode voltage doubler rectifier are reduced due to the presence of a series resonant circuit in the front-end converter. The operation of the proposed micro inverter is explained using an in-depth analysis of the switching characteristics of the power semiconductor devices. The theoretical analysis of the proposed micro inverter is validated using simulation results.

D1S4-2.2 3:15 ***A Fast Computing Algorithm for Microgrid Fault Protection System Using Communication-Assisted Digital Relays and Initially Experimental Results*** *278*

Lien Keng-Yu (China University of Science and Technology, Taiwan); Duong Minh Bui, Chen Shi-Lin and Zhao Wei-Xiang (Chung Yuan Christian University, Taiwan)

This paper presents a fast computing algorithm (FCA) for microgrid (μgrid) fault protection system. Aims of the fast computing algorithm are to online protect the μgrid system with high adaptability and dependability and to get the critical fault clearing time shorter than two cycles beginning at fault inception points. The FCA uses an overcurrent protection principle to protect branch lines in the μgrid system. These branch lines only contain different loads or distributed energy sources. In addition, in order to protect main lines in the μgrid from different fault occurrences, a new fault protection method is developed through using communication-assisted digital relays. This new fault protection principle uses three major parameters including: current, voltage and phase angle. The main lines are understood as lines used to interconnect two or more distributed energy sources and not including any load branches along these lines. As a result, the μgrid protection system using the FCA is inspected by two ways as the following. One is theoretical calculation which is done due to actual results of staged fault tests conducted at a real low-voltage μgrid - an INER microgrid at Taiwan (INER - Institute of Nuclear Energy Research). Besides the staged fault tests performed for the theoretical calculation, various tests such as power change of loads, motor starting tests and tests of μgrid's operation transition between grid-connected and islanded modes are also implemented at the INER μgrid. Purpose from all above tests is to validate effectiveness of the FCA for the μgrid fault protection system under both dynamic and transient conditions. Another way is inspection of the FCA in a lab environment, which uses FPGA (Field-Programmable Gate Array) boards as digital relays supported by communication network. Test results show that the FCA can quickly detect and identify different types of grounding fault and optimally isolate the faulted zones. Concretely, the fault clearing time for occurrence at the main lines is in a range of 0.5 - 2 cycles depending on algorithm's computation time and communication time among digital relays, while that for occurrence at the branch lines is directly dependent on the values of fault current.

D1S4-2.3 3:30 ***Control of a VSC-Diode Bridge Combination for Industrial Rectifier Applications*** *286*

Kalpani Thantirige (National University of Singapore, Singapore); Gamini Jayasinghe and Chandana Gajanayake (Rolls-Royce Singapore Pte Ltd, Singapore); Amit Gupta (National University of Singapore, Singapore)

This paper discusses the suitability of a voltage source converter (VSC)-diode bridge combination as a rectifier in industrial applications. This particular rectifier arrangement consists of a full rated diode bridge rectifier and a partially rated two-level voltage source auxiliary converter. This combination helps achieve power conversion at medium voltage with low voltage switching devices, improve current quality through pulse width modulation (PWM) operation and smoothen the dc-link voltage by transferring the ripples to the dc-side of the auxiliary converter. Moreover, this topology can be extended by replacing the two-level auxiliary converter with a multilevel converter such as diode-clamped three-level converter to achieve higher voltage levels and better power quality requirements. Apart from that, there is a possibility of interfacing energy storage devices through the dc-side of the auxiliary converter to mitigate power fluctuations. Control strategies and modulation techniques that are specific to the topology for different operating scenarios are simulated in MATLAB/Simulink. Simulation results are presented to verify the operation of the proposed topology.

D1S4-2.4 3:45 ***A First Step Towards Resilient Graph Partitioning for Electrical Grids*** *293*

Kazuhiro Minami, Nana Arizumi, Tomoya Tanjo and Hiroshi Maruyama (Institute of Statistical Mathematics, Japan); Yoshiki Yamagata (National Institute for Environmental Studies, Japan); Daisuke Murakami (National Institute of Environmental Studies, Japan)

We study a graph partitioning problem for electrical grids such that a given grid is partitioned into multiple ones that are self-contained concerning electricity balance. Our goal is to find a resilient partition against time-changing power demand and supply over the year. In this paper, we investigate two graph partitioning algorithms applying them to a synthesized dataset based on realistic assumptions about Yokohama, Japan. Our initial results show that a simple algorithm, which only considers horizontal or vertical partitions, possibly produces more resilient partitions than a more general algorithm whose partitions divide a graph into subgraphs of any topology.

D1S4-2.5 4:00 ***Renewable Energy Lamp to Replace Kerosene Lamp*** *299*

Haritha S Jayawickrama (University of Moratuwa, Sri Lanka)

Renewable energy is the current energy trend so that a new lamp which uses this energy type was built to replace the traditional kerosene lamp. Most of renewable energy sources produces clean power. Therefore room can be illuminated without polluting the environment. This does not produces hazardous fires & operational cost is minimum. People who live far away from the power delivery system depend on traditional kerosene lamp for light. Simple construction, availability of kerosene fuel enhanced this popularity. Kerosene fuel is burned incompletely to obtain the required illumination in this traditional method. This new lamp is built to store energy in a small battery when power is available. The power source can be small scale solar panel, wind turbine, or hydro power unit. The battery power is used in the night to obtain light. This lamp has a shape similar to traditional kerosene lamp. This lamp is energized with a small solar panel. Investment can be recovered in a short period. Risk of fire can be minimized due to absence of oil. Foreign revenue is saved because there is nothing to burn. This will convey renewable energy concept to the rural people. Life of the worlds' crude oil reservoirs can be extended with the new lamp. This will enhance the living standards of rural people.

D1S4-3: Information and Communication Technology

Room: Vip Lounge
Chairs: Amirthalingam Ramanan (University of Jaffna, Sri Lanka), Prasanna Gamage (Affiliation, Australia)

D1S4-3.1 3:00 ***GPU Based Non-Overlapping Multi-Camera Vehicle Tracking*** *305*

Tharindu D Gamage, Jayathu Samarawickrama and Ajith Pasqual (University of Moratuwa, Sri Lanka)

Vehicle tracking and surveillance is an area which is having a considerable attention in the context of security and safety. The detection and tacking of moving vehicles through multiple cameras is considered as a method of vehicle surveillance. This work addresses a problem of detecting and matching vehicles through multiple cameras. The power of GPUs are used to increase the number of video streams which can be processed using a single computer. In the detection process the Gabor filter is used as a directional filter and the SURF is used by the matcher to uniquely represent the vehicle

DS4-3.2 3:15 ***AugLAC - Generic Framework for Augmented Location Aware Commerce*** *311*

Mihiri Gunatunge and Yahani Hewagama (University of Moratuwa, Sri Lanka); Supun Gothama Hewawalpita (University Of Moratuwa, Sri Lanka); Indika Perera and Nipun Udara (University of Moratuwa, Sri Lanka)

In this paper we present AugLAC, a framework which integrates common features of location aware services, e-commerce and augmented reality into a single infrastructure for the development of location aware mobile applications. The research aim is to generalize the proposed framework to suit different business domains and to allow rapid development of applications using a component based architecture. Although this framework is mainly targeted for retail business domain it can be effectively used for other domains and use case scenarios where the basic principles apply.

D1S4-3.3 3:30 ***Novel Enhancements for Node Localization in Wireless Sensor Networks*** *316*

H. H. Samiru Gayan (University of Moratuwa, Sri Lanka); Dileeka Dias (University of Moratuwa, Sri Lanka)

Localization is a significant consideration in a Wireless Sensor Network (WSN), as it is essential to correlate sensor information with the geographic location it originates from. The DV-Hop algorithm, being a range-free, distributed algorithm, is an attractive option in this regard, due to its simplicity. In this paper, we present two algorithms to improve the localization accuracy of the DV-Hop algorithm. The Hop Size derived through a distributed fashion by the DV-Hop algorithm is optimized using the knowledge of the position of the anchor nodes. The locations of the unknown nodes are then estimated using the optimum hop size. We examine the performance of the proposed algorithms through simulations in environments with varying node numbers, anchor ratios and radio range. The results show that the proposed algorithms have improved performance in localization accuracy and stability compared to the original DV-Hop algorithm.

D1S4-3.4 3:45 ***Previous Hop Data Retransmission Service for SoR-based Public Networks*** *323*

Rajitha Tennekoon, Janaka Wijekoon, Erwin Harahap and Hiroaki Nishi (Keio University, Japan)

It is a well-known fact that the Internet traffic travels through public networks. These networks lack security and are highly congested. Transmission Control Protocol (TCP) use traditional Automatic repeat request (ARQ) method to retransmit data all the way from the sender. However, this method is widely used and operational, this method will introduce higher data retransmission delays and will unnecessarily duplicates packets further congesting the networks. To this end, our laboratory introduced the per-hop data encryption protocol for Service-oriented Router (SoR) based public networks to maintain rich information for the next-generation networks by shifting the current Internet infrastructure to an information-based and an open-innovation platform. An SoR can analyze all packet stream transactions on its interfaces and store them in high throughput databases. Using the features of the SoR, in this paper, we propose a previous hop data retransmission service for SoR-based public networks that provides per-hop data encryption. This infrastructure is proposing to provide higher data availability and reliability while preserving both the security and the privacy of data that traverses through public networks. We implemented a prototype of previous hop data retransmission service on the ns-3 simulator and the results obtained are discussed in this paper.

D1S4-3.5 4:00 ***Decentralized Reputation Based Trust Model for Peer-to-Peer Content Distribution Networks*** *329*

Shanika Ekanayake (CINEC Maritime Campus, Sri Lanka); Rajitha Tennekoon (Keio University, Japan); Ajantha Sanjeewa Atukorale (University of Colombo School of Computing, Sri Lanka)

Enormous content distribution systems improved broadly with the rapid growth of novel and innovative technologies. Peer-to-peer (P2P) content distribution network (CDN) technology is such innovative technological improvement which claims low cost, efficient data distribution and it gradually involves to next-generation CDNs. Moreover, real influence of P2P content delivery indicates with the ability of distributing high demand data with in a short period of time. Communications among the nodes of such open network infrastructures commonly perceived as an environment offering both opportunities and threats, which are based on trust issues. Thus, a trust mechanism is required to establish secure communication between the content delivery nodes. This paper introduces a novel, decentralized, cooperative and self-organized reputation based trust algorithm to mitigate the security complications of CDNs. To illustrate the trust model, a novel P2P hybrid network infrastructure has been introduced. Basically servers of that infrastructure arranged in tiers. The key notion of the research is to validate trust of the target before send or accept the traffic. Recommenders or peer content delivery nodes are involved with the trust validation process. Furthermore, performance of the proposed trust algorithm is evaluated through the ns-2 simulator in order to analyse the trusted and untrusted behavior of the P2P content delivery nodes.

4:30 PM - 4:45 PM

D1-Tea Break-2: Tea Break

4:45 PM - 6:00 PM

D1S5-1: Sustainable Systems in Disaster Management, Welfare, and Rehabilitation

Room: Salon Jasmine
Chair: A. G. Buddhika P. Jayasekara (University of Moratuwa, Sri Lanka)

D1S5-1.1 4:45 ***Detecting Wild Elephants Via WSN for Early Warning System*** ***335***

Madhavi Nakandala (University of Moratuwa, Sri Lanka)

The human elephant conflict in Sri Lanka has been going on ever since man started cultivating in areas frequented by elephants. As humans go further into the elephant occupied areas and changes in the land-use patterns, the elephant habitat is being continuously reduced. As a result, much of the present day elephant range extends into and overlaps with agricultural lands resulting in conflict with man. The government with the people has developed several solutions to mitigate this problem. However, still, the problem remains as it was. This paper is intended to design a sensor network to detect elephants as an early warning system. The proposed system is a virtual barrier rather than a physical one. A prototype system to detect elephants and send a warning message to the authorities and the villagers has been implemented. The wireless sensor network (WSN) has been setup as a virtual barrier covering elephant corridors or villages.

D1S5-1.2 5:00 ***Geo-enabled FOSS Tool Supports for Immediate Flood Disaster Response Planning*** ***341***

Kasun Sampath Ramanayake (Sri Lanka Institute of Information Technology, Sri Lanka)

Flood is a major natural hazard occur recurrently in Sri Lanka. Allocating victims to camps and provide medical facilities are two main activities at the immediate response phase of a flood and use of manual methods delayed this process. This project developed a geo-enabled application to support immediate response planning, mainly focusing on allocation victims to IDP camps, provide medical facilities, and supporting access avoiding already blocked roads based on administrative divisions of the affected area. Capacities and facilities in camps and hospitals are matched against the needs of the victims. It identifies the blocked roads, alternative routes to reach resource centers, camps and hospitals and provide navigation guidance. The tool can be used after a flood disaster, assuming basic demographic data and the current flood affected area data are available. The tool is developed as a plug-in for QGIS, a free and open source desktop Geographic Information System software. The tool is verified with sample data related to "Kaluthara" area. It is intended to integrate with InaSAFE disaster response support tool at a later stage.

D1S5-2: Sustainable Power and Energy Systems

Room: Orchid
Chairs: Visvakumar Aravinthan (Wichita State University, USA), Atputharajah Arulampalam (University of Peradeniya, Sri Lanka)

D1S5-2.1 4:45 ***Reactive Power Management of Co-located Residential PVs for Radial Distribution Systems*** *347*

Nimanthi Nandasiri, Abbas Gholizadeh, Chengzong Pang and Visvakumar Aravinthan (Wichita State University, USA)

Electricity plays an important and leading role in the flourishing of the world economy as sustainable and cost-efficient energy carrier for everyday needs. With the fast economic expansion in the developing areas, the cost of electricity has increased accordingly. The use of renewable distributed generation (DG) technologies and "green power" can provide a significant environmental benefit, and their costs continue to dropping. Utilities will try to get more injected renewable energy to our distribution network. This paper presents a reactive power management method based optimal power flow to calculate optimal DG power output and necessary voltages at buses and incremental costs in the distribution system integrating high penetration rate of renewable energy resources. The proposed method is able to minimize the electricity cost by cutting the power transferred from the grid and provide the co-optimized operation strategy for distribution system with residential photovoltaics (PVs), Case study is also presented to demonstrate the feasibility of proposal method.

D1S5-2.2 5:00 ***A New Transmission Expansion Planning Framework and Cost Allocation Method Considering Financial Transmission Rights*** *353*

Hossein Khazaei (Amirkabir University of Technology, Iran); Moein Sabounchi (Ferdowsi University, Iran)

In this paper, we propose a transmission expansion planning (TEP) framework combined with a cost allocation method based on cooperative game theory. It is a two-step model in which the first step includes the procedure of transmission expansion plan and the latter is comprised of cost allocation process. TEP is derived based on two criteria: reliability and the economic benefits and we use the cost of expected energy not supplied (EENS) to measure the cost of reliability. Both the energy markets and transmission rights are considered in calculation of the economic benefits of the transmission expansion plan on the market participants. Then the cost of the new/upgraded transmission facilities is allocated based on the cooperative game theory. The use of cooperative game theory and the proposed payment allocation method helps to distribute the social welfare gains among the market participants justly. A 6-bus test system is used to illustrate the effectiveness of the proposed TEP framework.

D1S5-2.3 5:15 ***Techno-Economic Analysis of Off-grid Hybrid Renewable Energy System for Sri Lanka*** *360*

Mohan Kolhe (University of Agder, Norway); K. M. Iromi Ranaweera (Norwegian University of Science and Technology, Norway); A g b s Gunawardana (University of Agder, Norway)

Off grid hybrid renewable energy based power systems for rural electrification has become an attractive solution for areas where grid electricity is not feasible. Hybrid systems use several generation technologies, therefore the selection of proper technologies and optimum sizing of the components has become of great importance in reducing the overall cost and increasing the reliability of the service. The focus of this study has been to investigate the optimum configuration of a hybrid system which can supply electricity to a rural community in Sri Lanka. A rural village from the Siyambalanduwa region in Sri Lanka inhabiting approximately 150 households resulting approximate daily electricity demand of 270 kWh has been studied. Several electricity generating technologies including solar, wind and diesel gen sets have been studied and the total net present cost of each system configuration has been calculated for 20 years of lifetime of system to examine the lowest energy cost option. It has been found that the combination of wind turbines, PV system, a battery bank and a diesel generator creates the optimum hybrid system following the rated capacities, wind - 40 kW, PV - 30 kW, battery bank - 222 kWh and the diesel generator - 25 kW. This system can supply electricity at an approximate levelized cost of 0.3 $/kWh.

D1S5-3: Knowledge Discovery in Biological Systems and Nano Technology

Room: Vip Lounge
Chairs: Sanjeeva Witharana, SMIEEE (University of Leeds, United Kingdom), Saman Halgamuge (The University of Melbourne, Australia)

D1S5-3.1 4:45 ***Network Generation in Disaster Affected Zones for Sustainable Development*** *365*

M Saravanan (Ericsson Research India & Ericsson Global India Private Limited, India); S Madan Kumar (Meenakshi Sundararajan Engineering College, India); G Vinnet (GITAM University, India)

In this paper, we propose an initiative for sustainable development with advanced growing Nanotechnology. We combined the vast scope of Nanomaterial with wireless networks and came up with a unique idea of generating a network zone in areas which are prone to be remote due to natural calamities. Nowadays, it is important for every human to stay connected with the world every second. Expectation to connect to the networks has been multiplied to a great extent for various purposes. One of the high priorities for the society is to provide immediate alternate infrastructure in the affected location to establish connection, but it is difficult to move on the road or by other means. The other reason may be the size of infrastructure which creates a problem to move and setup in the affected region. With the use of nanomaterial to reduce the size, we propose a contemporary smart pen cap sized device which can build networks in any short area. This device will be loaded up in a gun and can be fired from a distance of 500 meters. The device is capable of clinging onto any rigid surface and acts as a medium through which the network will be utilized. The device combines the boon of nanomaterial with wireless networks introducing a new practice for sustainable development during the time of catastrophes and provides immediate relief to the members get caught in the disaster locations. This proposed device has a vast scope since the usage of wireless networks is as crucial as survival of humanity and informs to the outer world the presence of the human beings thus securing help from society.

D1S5-3.2 5:00 ***Changes in Propagation Delays for Quantifying Pharmacological Effects on Cortical Cultures*** *371*

Dulini Mendis (University of Melbourne, Australia); Emma Morrisroe and Steven Petrou (Florey Institute of Neuroscience and Mental Health, Australia); Saman Halgamuge (The University of Melbourne, Australia)

Multielectrode arrays (MEAs) can be used to capture electrophysiological activity of neuronal cultures with high spatiotemporal resolution and have been successfully employed in detecting changes in activity in the presence of pharmacological additions. One of the key network dynamics of these cultures is spontaneous bursting that spans across the entire network and holds rich information content. In this work, we propose the use of normalized channel-wise propagation delays during such burst events for assessing the effect of pharmacological additions. Furthermore, we investigate multiple metrics based on propagation delays and show that they effectively identify changes induced by an analgesic (a substance with pain relieving properties). Our results show that the change in the proposed metrics induced by the analgesic is significantly more pronounced ($p = 0.003$-0.0147) than the change induced by control perturbations.

D1S5-3.3 5:15 ***Unsupervised Learning for Exploring MALDI Imaging Mass Spectrometry 'omics' Data*** *377*

Chalini Dilushika Wijetunge, Isaam Saeed, Berin Boughton and Ute Roessner (University of Melbourne, Australia); Saman Halgamuge (The University of Melbourne, Australia)

Matrix Assisted Laser Desorption Ionization - Imaging Mass Spectrometry (MALDI-IMS) is an emerging data acquisition technology in biological research. It has gained its popularity in 'omics' sciences because of its ability to explore the spatial distributions of various bio-molecules in detail. The sheer volume of data generated through this technology and the often limited a priori knowledge about the molecular compositions of biological samples, call for efficient data analysis methods. In this paper, first we review the available computational methods for analyzing the high-dimensional imaging datasets highlighting their advantages and limitations. Then, we propose a more recent unsupervised method as a means of exploring MALDI-IMS data and demonstrate its competency by extracting hidden significant spatial distribution patterns of a rat brain imaging dataset. Finally, we explain the potential future advances of 'omics' research associated with MALDI-IMS and the foreseeable challenges in analyzing the resultant data.

D1S5-3.4 5:30 ***On the Selection of Fitness Landscape Analysis Metrics for Continuous Optimization Problems*** *383*

Yuan Sun, Michael Kirley and Saman Halgamuge (The University of Melbourne, Australia); Mario A. Munoz (Universidad del Valle, Colombia)

Selecting an optimal algorithm for a given problem is non-trivial due to large amount of existing algorithms and high complexity of problems. A possible way to tackle this difficulty is to get better understanding of problem complexity. Fitness Landscape Analysis (FLA) metrics are widely used techniques to extract characteristics from problems. Based on the extracted characteristics, machine learning methods are employed to select the optimal algorithm for a given problem. Therefore, the accuracy of the algorithm selection framework highly relies on the choice of FLA metrics. Although researchers have paid great attention to designing FLA metrics to quantify the problem characteristics, there is still no agreement on which combination of FLA metrics should be employed. In this paper, we present some well-performed FLA metrics, discuss their contributions and limitations in detail, and map each FLA metric to the captured problem characteristics. Moreover, computational complexity of each FLA metric is carefully analysed. We propose two criteria to follow when selecting FLA metrics. We hope our work can help researchers identify the best combination of FLA metrics.

7:00 PM - 9:30 PM

D1-Banquet: Conference Banquet

Room: Anthurium

Tuesday, December 22

7:30 AM - 8:00 AM

Registration – D2: Registration

8:00 AM - 9:30 AM

D2S1-1: Intelligent Machines and Man-machine Co-existence

Room: Salon Jasmine

Chair: Saman S. Abeysekera (Nanyang Technology University, Singapore), Sisil Kumarawadu (University of Moratuwa, Sri Lanka)

D2S1-1.1 8:00 ***To Use or Not to Use: Graphics Processing Units (GPUs) for Pattern Matching Algorithms*** *389*

Vajira Thambawita (Uva Wellassa University, Sri Lanka); Roshan G. Ragel (University of Peradeniya & University of New South Wales, Sri Lanka); Dhammika Elkaduwe (University of Peradeniya, Sri Lanka)

String matching is an important part in today's computer applications and Aho-Corasick algorithm is one of the main string matching algorithms used to accomplish this. This paper discusses that when can the GPUs be used for string matching applications using the Aho-Corasick algorithm as a benchmark. We have to identify the best unit to run our string matching algorithm according to the performance of our devices and the applications. Sometimes CPU gives better performance than GPU and sometimes GPU gives better performance than CPU. Therefore, identifying this critical point is significant task for researchers who are using GPUs to improve the performance of their string matching applications based on string matching algorithms.

D2S1-1.2 8:15 ***Extensible Video Surveillance Software with Simultaneous Event Detection for Low and High Density Crowd Analysis*** *393*

Dilranjan Wickramasuriya and Anuruddha Hettiarachchi (University of Moratuwa, Sri Lanka); Heshani Thathsarani (WSO2 Inc., Sri Lanka); Pamuditha Udaranga Wickramasinghe and Ranga Rodrigo (University of Moratuwa, Sri Lanka)

Manual analysis of large volumes of video surveillance footage stemming from the widespread deployment of security cameras is error prone, expensive and time consuming. Despite the commercial availability of software for automated analysis, many products lack third party extensibility, the capability to perform simultaneous event detection and have no provision for anomaly detection in highly dense crowded scenes. We present a plugin based software system for video surveillance applications addressing these shortcomings and achieve realtime performance in typical crowded scenes. Core parameters are computed once per frame and shared among plugins to improve performance by eliminating redundant calculations. A novel multiple pedestrian tracking algorithm is incorporated into the framework to achieve the expected performance. We also propose an improvement to anomaly detection in densely crowded scenes using non-trajectory based dominant motion pattern clusters that can enhance the detection capability of the state-of-the-art.

D2S1-1.3 8:30 ***One-Pass Clustering Superpixels 399***

Kesavan Yogarajah and Amirthalingam Ramanan (University of Jaffna, Sri Lanka)

A superpixel is an image patch which is better aligned with intensity edges than a rectangular patch.Superpixels are perceptually consistent units which carry more information than pixels and adhere well to image boundaries. Nowadays superpixels are widely used for segmentation in computer vision and biomedical applications. There are many approaches to generate superpixels such as SLIC, QuickShift, Turbopixels and Normalized cuts algorithms, each with its own advantages and drawbacks that may be better suited to a particular application. In this paper we propose a one-pass clustering (OPC) technique to efficiently generate superpixels in the combined five-dimensional feature space of CIELAB colour and XY image plane. The Berkeley segmentation dataset (BSDS500) is used to quantitatively compare the performance of OPC with SLIC superpixels method as measured by boundary recall and under-segmentation error. OPC superpixels achieve comparable performance to previously reported results which allow a trade-off between a less regular space superpixels but accurate boundaries or better efficiency.

D2S1-1.4 8:45 ***Real-Time Fuzzy Logic Speed Tracking Controller for a DC Motor Using Arduino Due*** ***404***

Hasitha Ruwan Jayetileke, Ravi de Mel and Hemali Ratnayake (The Open University of Sri Lanka, Sri Lanka)

Designing and developing AI controllers on separately dedicated chips have many advantages. This paper reviews the development of a real-time fuzzy logic controller for speed control of a dc motor using Arduino Due board. The proposed fuzzy logic controller is based on Mamdani approach and has been tested on the aforementioned high performance microcontroller board and using MATLAB. During the real-time operation the dc motor behavior and the fuzzy controller's response were plotted and the data were stored in MATLAB without interrupting the fuzzy logic controller. Based on these observed information, the system settling time (Ts) and the rise time (Tr) reduction were calculated for each input wave patent trajectories while increasing the wave frequency. It was noted that the system overshoot (OS) is negligible. Utilizing the aforementioned parameters the Arduino Due board performance was analyzed with the fuzzy logic speed control approaches of dc motors made by past researchers as mentioned above. The system response shows a satisfactory performance for this particular dc motor application when the input signal (desired output signal) frequency is less than 2 Hz, but further research is needed when identifying the optimum performance of the Arduino Due board for different fuzzy logic algorithms while increasing the desired input signal frequency.

D2S1-1.5 9:00 ***Predicting Systolic Blood Pressure Using Machine Learning 410***

Tony Hao WU and Grantham Pang (The University of Hong Kong, Hong Kong); Enid Kwong (The Hong Kong Polytechnic University, Hong Kong)

In this paper, a new study based on machine learning technique, specifically artificial neural network, is investigated to predict the systolic blood pressure by correlated variables (BMI, age, exercise, alcohol, smoke level etc.). The raw data are split into two parts, 80% for training the machine and the remaining 20% for testing the performance. Two neural network algorithms, back-propagation neural network and radial basis function network, are used to construct and validate the prediction system. Based on a database with 498 people, the probabilities of the absolute difference between the measured and predicted value of systolic blood pressure under 10mm Hg are 51.9% for men and 52.5% for women using the back-propagation neural network. With the same input variables and network status, the corresponding results based on the radial basis function network are 51.8% and 49.9% for men and women respectively. This novel method of predicting systolic blood pressure contributes to giving early warnings to young and middle-aged people who may not take regular blood pressure measurements. Also, as it is known an isolated blood pressure measurement is sometimes not very accurate due to the daily fluctuation, our predictor can provide another reference value to the medical staff. Our experimental result shows that artificial neural networks are suitable for modeling and predicting systolic blood pressure.

D2S1-1.6 9:15 ***DOA Estimation of Harmonic Acoustic Signals*** **416**

Lu Wang and Lifan Zhao (Nanyang Technological University, Singapore); Xiumei Li (Hangzhou Normal University, P.R. China); Guoan Bi (Nanyang Technological University, Singapore)

In this paper, we propose a novel method to estimate the direction of arrival (DOA) of the harmonic acoustic signals received by a uniform linear sensor array. The wideband DOA estimation problem is formulated under Bayesian framework. The received signals are firstly divided into narrow sub-bands, and the sparsity in the angular domain in each sub-band is exploited to give a coarse estimation of the DOA. The unknown information on the sub-bands occupied by the received signals is extracted by imposing a Dirichlet process prior on the latent parametric space. Then a 1-D searching procedure based the reconstructed results and the obtained information of sub-band frequency occupation is used to give a refined DOA estimation. Results of numerical simulations show that the proposed method outperforms the one of the current state-of-the-art for harmonic acoustic signals.

D2S1-2: Robotics, Automation and Control

Room: Orchid

Chairs: Kenta Seki (Nagoya Institute of Technology, Japan), Tomoyuki Shimono (Yokohama National University, Japan)

D2S1-2.1 8:00 ***Sound Localization: Human Vs. Machine*** **422**

Nuwan Jayaweera, A. M. Harsha S. Abeykoon and A. G. Buddhika P. Jayasekara (University of Moratuwa, Sri Lanka)

The Human shows a remarkable capability in localizing a sound source and navigating towards it. In the current context of robotic applications, mobile robots have been developed, so that they too can be used for sound source localization. But, it is not yet undoubtedly quantified how accurately, the human is predicting the localization cues in different frequencies and distances at the free field than the machines. Thus, the aim of this paper is to estimate the error of localizing a sound source at different frequencies and distances on the azimuth plane within 360 degrees. An experiment is conducted to investigate the individual ability to predict the direction. Ten samples of 51sian young adults from the age group of 20 – 30 years are taken into the experiment and their responses for localization cues are recorded. The experiment is also conducted for different sound source locations such as 1m, 2m and 3m and different source frequencies of 1 kHz and 5 kHz. Results show that the accuracy of human in predicting the front directions is higher than that of back directions and the error for predicted direction by human is less than that of developed machine sound localization algorithms at different distances.

D2S1-2.2 8:15 ***Strategies for Energy-oriented Process Control: Requirements on Use Case of Container Handling*** **428**

Dirk Schöttke, Thomas Kämpfe and Shalika Prageeth Kulasekara (HTW Berlin – University of Applied Sciences, Germany); Nishal Dayarathne (University of Moratuwa, Sri Lanka); Stephan Schäfer (HTW Berlin – University of Applied Sciences, Germany); Ulrich Berger (Brandenburg University of Technology (BTU) Cottbus-Senftenberg, Germany)

For some time, the environmental and resource protection is the key issue in the industrial environment. In order to achieve the ambitious energy goals, the plants and systems involved in the process must be analyzed and evaluated in terms of its optimization potential. In the use case of container handling this concerns the optimization of processes, the aspects of resource use and the possible load flexibility. The issue of load flexibility is essential, because there are an increasing decentralization of energy supply and a changing design of the power grids. Strategies for energy-oriented process management may specifically influence the systems involved in the process. Considering the overall system (inclusive resources use), future solutions can be designed more flexible compared to classic load management solutions. In the article Several conditions and possible interfaces are described for the use case of an energybased control strategy.

D2S1-2.3 8:30 ***Simulation of Brake by Wire System with Dynamic Force Control*** *434*

W. A. Shanaka P. Abeysiriwardhana and A. M. Harsha S. Abeykoon (University of Moratuwa, Sri Lanka)

"By wire" technology is recently developed to improve the reliability, safety, and performance of vehicle drive technology. Brake system is the most important control system for vehicle safety. "By wire" technology development has encouraged the development of brake by wire systems to reduce traditional mechanical and hydraulic systems usage in automobiles. This paper proposes a novel brake by wire controller that uses a reaction force based motor controlling method. The proposed system uses two linear motors with disturbance observer and reaction force observers to provide pedal force amplification and pedal retraction capabilities in the brake by wire system. The system includes a force controller to provide pedal feel to drivers. The proposed system is simulated for different conditions to measure the performance and robustness. The simulation results provide evidence for robustness, force amplification, and pedal and brake retraction capabilities of the system.

D2S1-2.4 8:45 ***Simulation of Enhanced Force Limiting Gripper for Bilateral Teleoperation*** *440*

R. M. Maheshi Ruwanthika and A. M. Harsha S. Abeykoon (University of Moratuwa, Sri Lanka)

This paper proposes an enhanced force limiting gripper to avoid object deformation when it is in contact with the slave due to excessive forces imposed by the master operator in bilateral control. The force lock protects the gripped object on the slave and the attainment of the force limit is notified to the master operator via a small vibration. Master operator is expected to experience a spring effect if the operator presses his leaver towards the force increasing direction. The continuous copying of the slave position as the reference to the virtual spring controller's spring equilibrium point allows smooth releasing. In addition to vibration the loss of reaction force coming from the slave environment could also be sensed by the master operator. Reversing of the applied force on master handle releases the object attached to the slave. In this proposed system sensor-less sensing is used. Disturbance Observer is used to estimate disturbances and Reaction Force Observer estimates reaction forces. The proposed gripper is having a jaw opening of 0.15 m which has linear 1-DOF. Simulation is conducted using real world linear motor parameters and simulation results prove the applicability of proposed system.

D2S1-2.5 9:00 ***Photovoltaic-Battery Hybrid Power Supply Applied with Advanced-Time-Sharing Switching Technique and Discrete Ripple Correlation Control*** *446*

Liang Xian and Youyi Wang (Nanyang Technological University, Singapore)

Maximum power point tracking (MPPT) is usually desirable in photovoltaic (PV) power applications. The scenario of load demand in excess of power capability that a PV device can provide requires a hybrid power supply (HPS) to employ additional power sources (e.g. AC-line supply or battery power system) for maintaining output voltage regulation (OVR) and MPPT. Such a HPS, in this study, is topologized with a double-input buck conversion circuit which is proven to possess higher efficiency, less component count, lower cost and simpler manipulation, comparing with those conventional parallel-connected single-input single-output converters. Advanced-time-sharing switching (ATSS) scheme for PWM switching function generation is developed and utilized to implement smooth and accurate adjustment to output power produced by power sources, without losing OVR, MPPT, and single-input equivalent circuit analysis convenience. Discrete ripple correlation control is selected to realize MPPT. This paper brings forward the theoretical and mathematical interpretation to the aforementioned procedures as well as the simulation-level verification and performance testing.

D2S1-3: Special session on Sustainable Energy Usage and Distribution

Room: Vip Lounge
Chairs: Anjula De Silva (University of Moratuwa, Sri Lanka), Upeka Premaratne (University of Moratuwa, Sri Lanka)

D2S1-3.1 8:00 ***Selecting an Optimal Combination of Storage & Transmission Assets with a Non-Dispatchable Electricity Supply*** *452*

Khalid Abdulla and Andrew Wirth (University of Melbourne, Australia); Saman Halgamuge (The University of Melbourne, Australia); Kent Steer (IBM Research, Australia)

The majority of renewable energy sources are non-dispatchable, meaning that it is not possible to control when and how much power they produce. For non-dispatchable renewable energy sources to meet a greater proportion of global electricity demand, the industry must develop and implement strategies that directly address the intermittency challenge. This paper considers electrical storage and transmission assets as alternative means of matching non-dispatchable generation with non-deferrable demand. It seeks an optimal combination of storage and transmission assets for a simplified representation of Australian population centres, assuming that demand is met entirely with solar PV generation. This problem is solved using a Mixed Integer Linear Program. Under the baseline assumptions it is found that the optimal (lowest cost) solution has significant quantities of storage in all load centres, as well as transmission assets installed over large distances. The storage selected was 10-15% Li-ion batteries by energy; with the remainder being pumped hydro storage.

D2S1-3.2 8:15 ***Flexible Graph Partitioning of Power Grids with Peer-to-peer Electricity Exchange*** *458*

Kazuhiro Minami, Tomoya Tanjo, Nana Arizumi and Hiroshi Maruyama (Institute of Statistical Mathematics, Japan)

We study a clustering problem for electrical grids. Our goal is to find an optimal partition that minimizes the cost of constructing a set of self-sufficient microgrids. To obtain a better solution accommodating smaller microgrids, we develop a verification algorithm that determines whether microgrids can balance their electricity surplus through electricity exchange with each other. Our preliminary results show that our proposed method can effectively reduce the construction cost of decentralized microgrids.

D2S1-3.3 8:30 ***Increasing the Thermal Efficiency of an Operational Data Center Using Cold Aisle Containment*** *464*

Ali Habibi Khalaj (University of Melbourne, Australia); Thomas Scherer (IBM Research, Switzerland); Jayantha Siriwardana and Saman Halgamuge (The University of Melbourne, Australia)

Cooling systems play a vital role in the design and operation of Data Centers (DCs), as they consume a considerable amount of energy. Hot air infiltration from the servers' outlets into their inlets, which creates hot spots and flow short-circuiting, is one of the main sources of thermal inefficiency inside air-cooled DCs. This inefficiency increases the total energy consumption of DCs especially when the allocated workload and heat dissipation of the servers are increased. Therefore, efficient thermal management of DCs is considered as one of the main challenges of the DC industry. In order to highlight the importance of this inefficiency, an operational DC has been considered in this study. The thermal behaviour of the DC has been evaluated by conducting a numerical analysis of the flow and temperature fields based on the experimental measurements in a real DC. Numerical simulation highlighted a number of undesirable hot spots near the racks. Cold aisle containment, which is one of the efficient and industrially affordable methods of thermal inefficiency reduction, has been considered. The effectiveness of this method has been evaluated using three non-dimensional metrics known as Supply Heat Index (SHI), Rack Cooling Index (RCI) and the Coefficient of Performance (COP) of the cooling system. In this case study, by applying the proposed method, SHI, RCI and COP of the cooling system have been improved by more than 0.45, 17% and 19.5%, respectively. These results demonstrate the effectiveness of cold aisle containment for energy efficiency enhancement of DCs.

D2S1-3.4 8:45 ***An Innovative Software Tool for Enhanced Building Life Cycle Management and Maintenance Forecasting Deployed Via Cloud*** *470*

Kanishka Atapattu, Sujeeva Setunge and Guomin Zhang (RMIT University, Australia)

Community buildings are one of the largest infrastructure assets invested and managed by local governments in Australia. An optimised expenditure projection model which ensures building assets are maintained at a required level of service requires a reliable deterioration model for building components and a decision making algorithm which captures sustainability. Prediction of deterioration and decision making methods for community buildings have been explored by RMIT University in a research project conducted in collaboration with six Australian local councils and the Municipal Association of Victoria. A web-based software tool has been developed to enable buildings asset managers to make informed decisions for maintenance and rehabilitation activities of building assets. The software tool uses a probabilistic deterioration prediction model to reflect the stochastic nature of condition degradation to model variety of building components. Risk and expenditure forecasting based on Markov Chain deterioration prediction are generated within the program. Consequently, scenario analysis assists not only in organisational risk threshold identification based on levels of service, but also in funding allocation to attain required building performance. The software integrates a quadruple bottom line sustainability factors to enable decision makers in considering environment, social, economic and functional aspects of decisions for community buildings. The paper presents the algorithm of the software, challenges in integrating multiple modules, the analytical modules, input data and outcomes of forecasting for a data set from a City Council in Victoria, Australia.

D2S1-3.5 9:00 ***Tie-Line Bias Control and Oscillations with Variable Generation in a Two-Area Power System (Invited Paper)*** *476*

G. Kumar Venayagamoorthy (Electrical and Computer Engineering, Clemson University & Real-Time Power and Intelligent Systems Laboratory, USA); Iroshani Jayawardene (Clemson University & Real-Time Power and Intelligent Systems (RTPIS) Laboratory, USA); Paranietharan Arunagirinathan (Clemson University, USA)

Integrating variable generation sources such as utility-scale photovoltaic (PV) plants into the transmission grid is desirable with the increasing quest for cleaner sources of electric power generation and reducing cost of utility-scale PV. In a multi-area power system, inter-area flows have to be controlled according to some power purchase agreements and transaction contracts. The power fluctuations from large PV plants raise operation and stability challenges. Automatic generation control (AGC) with knowledge of PV plant generation is introduced for variable tie-line bias control and maximum utilization of PV power in the power system. Typical results are presented on a two-area four machine power system with a utility-scale PV plant to illustrate the proposed real-time AGC control. Furthermore, an analysis of the tie-line power oscillations due to cloud cover and disturbances for different levels of PV power penetration are carried out.

9:30 AM - 10:30 AM

D2-Keynote: Keynote on an ICT Platform for Automated Monitoring of the Quality of Drinking Water.

Prof.Clarence W. de Silva
Room: Bougainvillea Ballroom
Chair: Nalin Wickramarachchi (University of Moratuwa, Sri Lanka)

This talk will address several important aspects of research and development leading to an ICT (information and communication technologies) platform for automated sensing, quality monitoring, assessment, information management, and decision making of drinking water. The addressed key issues are: (a) Automated and remote sensing issues of water quality monitoring; (b) Signal processing and transmission issues; (c) Architecture of the ICT platform; (d) Knowledge-based decision making, with self-adaptation and self-optimization; (e) Utilization of the acquired knowledge for short-term and long-term purposes; and (f) Societal impact of the developed technologies on community health. Water comes into contact with minerals, salt, vegetation, toxic chemicals, and biological waste, and is never completely pure. Many of these contaminants may pose health risks. About 3.4 million people die every year in the world due to waterborne diseases, and poor sanitation. Regular monitoring of the quality of drinking water and taking proper actions to improve its quality is important for healthy living. This is particularly important in rural areas and underprivileged communities. The developed system consists of multiple sensor nodes that are geographically distributed and have the capability of wireless communication to local microcontrollers. After some basic processing, the gathered information is transmitted by the microcontrollers to a central assessment unit. The system analyzes the geographic and temporal information and provides advisories, warnings, trends, forecasts, and suggested actions. Robustness, speed, low-cost, and user-friendliness are key features of the developed system.

10:30 AM - 10:45 AM

D2-Tea Break-1: Tea Break

10:45 AM - 11:30 AM

D2-Plenary: Plenary speech on Nonlinear Separation Model and Control: Development of Theory based on Practice

Professor Masatoshi Nakamura
Room: Bougainvillea Ballroom
Chair: Rohan Munasinghe (University of Moratuwa, Sri Lanka)

My research and teaching are based on my passion for systems control linked to development of theory and practical implementation. I engage in systems control across several fields such as mechatronic systems and robotics, power and plant systems and biomedical systems. It encompasses the creation of innovative methods and theories for identification, estimation, control and signal processing through problem solving in industry, medical sector, and in the society by way of persistent and close collaboration with the specialists in respective fields.

11:30 AM - 12:30 PM

D2S2-1: Intelligent Machines and Man-machine Co-existence

Room: Salon Jasmine
Chairs: Indika Perera (University of Moratuwa, Sri Lanka), Roshan G. Ragel (University of Peradeniya & University of New South Wales, Sri Lanka)

D2S2-1.1 11:30 ***Detection of Respiratory Paradoxical Movement via Doppler Radar Measurements*** *482*

Yee Siong Lee and Pubudu Pathirana (Deakin University, Australia); Christopher Louis Steinfort (FRACP, Australia)

This paper presents an evaluation of microwave Doppler radar in capturing the respiration signal from the chest and abdomen simultaneously using two radar systems. Two experiments were conducted to investigate the feasibility of using Doppler radar in measuring respiration from both chest and abdomen simultaneously. Results obtained indicate that the respiration patterns from the radar were highly correlated with the reference respiration strap readings for normal breathing scenarios and also sensitive enough in capturing the paradoxical movement between the chest and the abdomen in the professionally role played experiments.

D2S2-1.2 11:45 ***Facilitating Communication and Computer Use with EEG Devices for Non-Vocal Quadriplegics*** *487*

Gareth Williams and Yee Siong Lee (Deakin University, Australia); Larissa Andriske (Barwon Health, Australia); Samitha W Ekanayake and Pubudu Pathirana (Deakin University, Australia)

This paper tackled the problem of establishing a computer brain interface using an Electroencephalography device for the purposes of interfacing with a computer using software developed in house for non-vocal quadriplegics. The hardware used was an Emotiv EEG that was used with a novel interface in order to establish some form of voice communications.

D2S2-1.3 12:00 ***Students Behavioural Analysis in an Online Learning Environment Using Data Mining*** *492*

Iroshini P Ratnapala (University of Peradeniya, Sri Lanka); Roshan G. Ragel (University of Peradeniya & University of New South Wales, Sri Lanka); Sampath Deegalla (University of Peradeniya, Sri Lanka)

The focus of this research was to use Educational Data Mining (EDM) techniques to conduct a quantitative analysis of students interaction with an e-learning system through instructor-led non-graded and graded courses. This exercise is useful for establishing a guideline for a series of online short courses for them. A group of 412 students' access behaviour in an e-learning system were analysed and they were grouped into clusters using K-Means clustering method according to their course access log records. The results explained that more than 40% from the student group are passive online learners in both graded and non-graded learning environments. The result showed that the difference in the learning environments could change the online access behaviour of a student group. Clustering divided the student population into five access groups based on their course access behaviour. Among these groups, the least access group (NG-41% and G-42%) and the highest access group (NG-9% and G-5%) could be identified very clearly due to their access variation from the rest of the groups.

D2S2-2: Robotics, Automation and Control

Room: Orchid

Chairs: Kenji Natori (Chiba University, Japan), Nalin Wickramarachchi (University of Moratuwa, Sri Lanka)

D2S2-2.3 12:00 ***Effective T-S Fuzzy Model for Decentralized Control*** **518**

Qianfang Liao, Wenjian Cai and Youyi Wang (Nanyang Technological University, Singapore)

In order to facilitate decentralized fuzzy controller designs for multi-input-multi-output (MIMO) processes, this paper presents a novel manner, called effective Takagi-Sugeno (T-S) fuzzy model (ETSM), to describe the interactions among the loops. For a certain control-loop of an MIMO process, in terms of relative normalized gain array (RNGA) based loop pairing criterion, simple calculating procedure is given to obtain an ETSM based on its individual open-loop T-S fuzzy model. With the ETSMs of control-loops, an MIMO process can be approximately regarded as multiple non-interacting single loops such that each local controller of a decentralized control system can be independently designed using linear single-input-single-output (SISO) control algorithms. Compared with the existing decentralized fuzzy control methods adding extra terms to individual open-loop models to characterize interactions, ETSM is a practical and low-cost way. While compared with the existing effective transfer function (ETF) methods, ETSM is an extension that can proceed without requiring exact process mathematical functions, and lays a basis to develop robust controller since fuzzy system is strong in handling uncertainties. In case study, a nonlinear MIMO process is used as an example to demonstrate the effectiveness of the proposed ETSM method.

D2S2-2.4 12:15 ***Application of T-S Fuzzy Controllers on an HVAC System*** **524**

Long Teng, Youyi Wang, Can Chen, Wenjian Cai and Hua Li (Nanyang Technological University, Singapore)

This paper focuses on designing fuzzy controllers for a kind of Heating, Ventilation, and Air Conditioning (HVAC) systems. A kind of fuzzy method based on T-S fuzzy models with nonlinear local feedbacks is applied to a specific HVAC system. Firstly, an augmented HVAC system model is got based on an existing model. Then control with T-S fuzzy systems with nonlinear local models is reviewed. The control gain is got by solving a set of linear matrix inequalities (LMIs) where H∞ performance is considered. Finally, simulations and comparisons are executed to illustrate the effectiveness of this kind of fuzzy methods.

D2S2-3: Sustainable Power and Energy Systems

Room: Vip Lounge

Chairs: Junichi Arai (Kogakuin University, Japan), Nilakshi Lidula (University of Moratuwa, Sri Lanka)

D2S2-3.1 11:30 ***Spectrally Smoothed Polynomial Fourier Transform for Time-Frequency Characterization At Low SNR*** **530**

Saman S. Abeysekera (Nanyang Technology University, Singapore)

Frequency Modulated (FM) signals are encountered in many natural and human-made applications in earth, oceanic and atmospheric environments. In this paper, the limitations and optimality of existing FM signal characterization methods, in particular at low signal to noise ratios are investigated. For proper characterization, the selection of a time-frequency representation through spectrally smoothed Polynomial Fourier transform is proposed. The efficiency and the optimality of the method are elaborated.

D2S2-3.2 11:45 ***Power System Switching Transients in Passenger Automobiles*** *536*

Earl A.R.L. Pannila and Chaminda Edirisinghe (University of Colombo, Sri Lanka)

The design of modern automobiles has already reached to a level that many uses highly complex and sophisticated computing applications with associated electronics. These high-ended car electronic automation systems require very accurate and steady supply and most of these sensitive car electronics like multimedia systems, GPS units, etc., prone to fail in the presence of transient over voltages through the DC supply lines. Therefore a measurement of transients in automobiles and analysis has been done in order to identify the characteristics and risk levels of such transients for the vehicular control and attendant systems. In evaluating, an extensive survey of the transients carried out at a constant location within the electrical system of many late model automobiles. Transients were measured, rise times ranging from 0.3 us to 700 us and pulse durations from few microseconds to hundreds. There are bursts spread over milliseconds while number of transients have rise and fall times (< 5 ns) in the RF range (> 200 MHz). Thus the transient waveforms were first categorized to arrive at a compact set of common types of waveforms and analyzed. The measured transient parameters were compared with the sensitivity of several standard car electronic devices to identify their immunity to the conducted transients. Providing an overview of how to mitigate or reduce the effect of transients in automobiles in order to increase the power system efficiency and reliability, also expected while addressing the sensitivity of devices.

D2S2-3.3 12:00 ***Study on Impact of Wind Power Park Integration on Weak Power Systems: A Case Study on Mannar Wind Park in Sri Lanka*** *542*

Asanka S Rodrigo (University of Moratuwa-Sri Lanka, Sri Lanka); Obinamuni Supun D De Silva, V Isuru Pasan Dasanayake, H. K. C. Oshan Dayarathne and J. G. Dilina Sanjeevan De Silva (University of Moratuwa, Sri Lanka)

Wind power is one of the largest sustainable alternative energy source used in the world for power generation. Though wind resource rich areas are available widely in Sri Lanka, excessive development of wind power plants would affect negatively on the system operations and system stability. Therefore, necessary power system analysis should be performed to determine the maximum wind penetration level into the national grid at an identified wind resource rich region. Since Mannar is identified as the prospective wind park development zone, steady state and dynamic system analysis were performed on the proposed transmission network for the year 2017 with four stages of Mannar wind development. The paper presents identified system constraints, recommended remedial actions and the final conclusion on the maximum wind penetration level from Mannar Wind Park for the year 2017.

D2S2-3.4 12:15 ***Transients in Low Voltage Power Systems (LVPS) in Sri Lanka Under Modern Domestic Environment*** *548*

Earl A.R.L. Pannila and Chaminda Edirisinghe (University of Colombo, Sri Lanka)

A life in modern society without safe and reliable supply of electricity is almost unimaginable, as it plays an indispensable role in human life. This reliability, essentially the balance is very important for safe operation of electronic appliances, but failures by transients become more prevalent due to their higher susceptibility of control circuits. Therefore either it should be reduced or eliminated in order to keep the mains safe and clean for other electrical appliances. Even though time duration that the electrical transients are present in the system is short, the components in the system are subjected to high-current and high-voltage peaks that can cause catastrophic damage. In order to identify this formidable menace, 1148 transient waveforms were recorded in LVPS in Sri Lanka under modern domestic environment. These recorded transients were due to induce over-voltages under lightning, switching, loading, energizing, etc. Through an empirical analyses carried out to extract the parameters of transients in LVPS in Sri Lanka, the highest positive peak of 472 V, negative peak of 448 and the highest amplitude of 815 V were recorded. Burst width as high as 1.338 ms is also reported. Rise times are as short as 15 ns for impulsive transients and 0.1 us for oscillatory transients calculated. Results may be used to identify and understand the behavior of transients by correlating the major components in transients to the operated electrical appliance and to develop proper transient protection systems.

12:30 PM - 1:15 PM

D2-Lunch: Lunch

1:30 PM - 3:00 PM

D2S3-1: Sustainable Power and Energy Systems

Room: Salon Jasmine

Chairs: Junichi Arai (Kogakuin University, Japan), Mohan Kolhe (University of Agder, Norway)

D2S3-1.1 1:30 ***Designing Smart Hybrid Renewable Energy Systems with V2G*** *554*

A. T. D. Perera and Ashen R. Wijesiri (University of Moratuwa, Sri Lanka)

A novel computational tool to model, simulate and optimize grid connected HESs with V2G is presented in this study. A mathematical model is combined with a simulation algorithm to evaluate energy flows through the system devices and life cycle cash flow. Life-cycle cost of the system is taken as the objective function to be optimized in order to obtain optimum system configuration. Type and capacity of Solar PV (SPV) panels and wind turbines, and size of V2G charging center were taken as decision space variables. An evolutionary algorithm is used to arrive at the optimum system design considering level of grid integration as a constraint. Finally, sensitivity of grid cost on system configuration and energy flow is evaluated.

D2S3-1.2 1:45 ***A Novel Simulation Based Evolutionary Algorithm to Optimize Building Envelope for Energy Efficient Buildings*** *559*

A. T. D. Perera and M. P. G. Sirimanna (University of Moratuwa, Sri Lanka)

Building envelope plays a vital role in energy efficient buildings. This study introduces a novel simulation based optimization algorithm to minimize the net thermal load of buildings through optimizing envelope. Ten parameters related to the building envelop, including aspect ratio of the building, window to wall ratio, building orientation, roof material, wall material etc were taken as the decision space variables. A mathematical model is developed to evaluate the energy flow of the building on hourly basis. The model is amalgamated with a simulation algorithm to evaluate the hourly averaged thermal load of the building (considering one year), which is taken as the objective function to be optimized. A constraint, mono-objective optimization algorithm is used to optimize the objective function considering total window area as a constrained. Finally, the impact of the total window area on the optimized results is analyzed through a sensitivity analysis.

D2S3-1.3 2:00 ***Short-term Forecast for Photovoltaic Power Generation and Development of Measuring Equipment*** *565*

Hiroaki Kobayashi and Junichi Arai (Kogakuin University, Japan)

Photovoltaic power generation is a promising measure for the reduction of fossil fuel consumption and so is widely utilized in the world. However, its output power highly depends on the weather condition. In power systems, an energy management system controls generation to maintain power quality, then a change of generating power from the photovoltaic generation affects power system operation. This paper proposes a new feasible forecasting method for the electric output of photovoltaic power generation. The method uses solar radiation data measured at several points, and estimates changes of the photovoltaic power generation mainly due to clouds. The measuring equipment is developed and is located at several points which are 30 km away from the photovoltaic power generation. The correlations between these data are analyzed, and it shows the forecasting method will be applicable to actual power systems.

D2S3-1.4 2:15 ***Experimental Analysis of a Hybrid Ejector-based Air-conditioning System Using R134a*** *571*

Hao Wang and Wenjian Cai (Nanyang Technological University, Singapore)

This paper describes the experimental study of a hybrid ejector-based air-conditioning system using R134a. The proposed system can be operated under different modes. A series of experiments have been conducted to investigate the effect of the generating, condensing and evaporating pressure on the system performance and entrainment ratio. The results indicate that: the performance of hybrid system is sensitive to the three pressures; the coefficient of performance (COP) of hybrid mode is around 35% higher than that of general mode.

D2S3-2: Soft and Underactuated Robots, Robotics and automation

Room: Orchid
Chairs: Thrishantha Nanayakkara (King's College, University of London, United Kingdom), Upeka Premaratne (University of Moratuwa, Sri Lanka)

D2S3-2.1 1:30 ***Estimation of Prosthetic Arm Motions Using Stump Arm Kinematics*** **577**

Isuru Dasanayake, R. A. Ruwan Chandra Gopura and Palitha Dassanayake (University of Moratuwa, Sri Lanka); George Mann (Memorial University of Newfoundland, Canada)

This paper proposes two kinematic based task classification methods for a transhumeral prosthesis. The first method is a neural network based classifier where the angles of shoulder flexion/extension, shoulder abduction/adduction and elbow flexion/extension are considered. The angular values with their first and second derivatives are obtained to train the robotic arm for selected set of tasks. The second method is fuzzy logic based classifier where the angles of the aforementioned motions are divided into angular positions such that each combination of the above motions performs a specific predefined task. Therefore, more tasks can be defined with the combinations of the angular positions of the motions. The effectiveness of two task classification methods is verified experimentally.

D2S3-2.2 1:45 ***Challenges in Developing Soft Tactile Sensors for Robots That Detect Incipient Slip*** **583**

Katudampe Vithanage Damith Suresh Chathuranga, Wang Zhongkui and Shinichi Hirai (Ritsumeikan University, Japan)

This paper focuses on tactile sensors capable of detecting incipient slip. First, a review on the state of the art in incipient slip detection technologies is conducted. Next, we explain tactile perception of the human hands, emphasising on the incipient slip sensing. The mechanism of incipient slip is explained via displacement and acceleration results of a finite element analysis (FEA) conducted on a biological fingertip. Next, an example for the usage of incipient slip detection to manipulate objects is presented. Later, the requirements for a robotic tactile system capable of detecting incipient slip is stated. Finally, challenges in developing sensors for tactile perception particularly in the application of incipient slip detection is presented.

D2S3-2.3 2:00 ***Passive Dynamics of High Frequency Bat Wing Flapping with an Anisotropic Membrane*** **590**

Michael Zheng, Seyedmohammadhadi Sadati and Pendar Ghalamchi (King's College London, United Kingdom); Thrishantha Nanayakkara (King's College, University of London, United Kingdom)

We investigate how unmanned aerial vehicles (UAVs) with flexible wings can be designed to exploit the aeroelasticity of wing deformation that is present in bat wings, with a view to improve the efficiency of flight. We constructed a robotic bat wing with fully passive elastic wing-folding properties. The robotic wing is powered by a gearbox running two synchronised motors, effectively providing one degree of motion: the upstroke and down-stroke of the wing. Through numerical simulations and setup experiments, we observed that by integrating a span-wise elastic network into the bat wing, we were able to achieve passive wing-folding that mimics the 8-shape wing-folding seen in bats' high speed flight. This way, we were able to reduce the complexity and additional actuation associated with wing-folding in a robotic wing.

D2S3-3: Information and Communication Technology

Room: Vip Lounge
Chairs: Yougarajah A. Charles (University of Jaffna, Sri Lanka), Prasanna Gamage (Affiliation, Australia)

D2S3-3.1 1:30 ***Sensor Network Based Device Free Intrusion Detection and Localisation*** ***596***

Prasad Sampath (Dialog - UoM Mobile Communications Research Laboratory, Sri Lanka); Ruwini Edirisinghe (RMIT Univerity, Australia); Dileeka Dias (University of Moratuwa, Sri Lanka)

Device free detection and localization is a promising and a very practical research area where installation of expensive sensors and/or tagging the intruder is not feasible. This paper reports a mesh network developed for device free intrusion detection. We use the Received Signal Strength Indicator (RSSI) measurements of the wireless links within the mesh as the sole sensing mechanism. A fingerprint of RSSI measurements characterizes the environment under normal conditions including multi-path effects. A technique to differentiate RSSI variations due to intrusions from those due to multi-path effects is demonstrated. The results of the experiments conducted in an outdoor environment have verified that the proposed method can be used to detect intrusions successfully. The reliability of the detection is improved by cross-correlating RSSI variations among the multiple links in the mesh. The ability to extend the system for localization is also investigated.

D2S3-3.2 1:45 ***A Survey on Methodologies for Runtime Prediction on Grid Environments*** ***602***

Sena Seneviratne (Sydney University, Australia); Sanjeeva Witharana (University of Ruhuna, Galle, United Kingdom)

The accurate prediction of runtimes of future job tasks on the nodes of a grid supplies vital information for the users to make CPU resource usage decisions. There are number of different approaches to predict runtimes of the future job tasks. These approaches range from the statistical to non statistical and some of them require expensive search algorithms or availability of the source code of job tasks. In this paper we discuss about the existing such methods and categorise them according to a certain taxonomy. Then we compare the advantages and disadvantages of them with that of the Task Profiling Model for Host Load Profile Prediction which is developed by the authors.

D2S3-3.3 2:00 ***Post Failure Recovery of Virtual Coordinates in Wireless Sensor Networks*** ***608***

Gunjan Mahindre and Anura P Jayasumana (Colorado State University, USA)

Virtual Coordinate (VC) based algorithms possess many advantages for large scale sensor networks. They rely on the validity of VCs of network nodes. VCs are affected by events such as node failures which are unpredictable and inevitable in WSNs. This degrades the performance of the algorithms and also reduces overall life of the network. A distributed algorithm is presented for fault detection and recovery of VCs due to node failure. Consistency of VCs is used to detect failures and affected VCs are recovered without the need to regenerate VCs by flooding the entire network. Performance of the VC repair algorithm is evaluated under different conditions. VC repair packets propagate in localized neighborhoods, the extent of which adapts to the nature of the failure. This helps to attain efficient performance for all network sizes. The algorithm helps the network recover gracefully from degradation in performance in response to sudden node failure patterns. It also helps enhance the performance of all the operations dependent on VCs and their validity.

D2S3-3.4 2:15 ***GPU Based Acceleration for Fergus' Image Deblurring Alogrithm*** **614**

Geethan Karunaratne, Pamuditha Udaranga Wickramasinghe and Jayathu Samarawickrama (University of Moratuwa, Sri Lanka)

Image Deblurring algorithms have been evolving over many decades. Even though there are many algorithms available today that produce reasonably good results, their speed of execution does not make them appealing for many real time applications. Thus we address this issue by improving the speed of execution of an existing algorithm using parallelization and other optimizations. The algorithm we selected was published by Fergus et al. in 2006, for which a 10x speed up improvement was achieved. Many other authors have since followed his approach and have come up with different variants of the solutions to which our implementation could be readily extended to improve the run-time.

D2S3-3.5 2:30 ***Spectrum Sensing in Cognitive Radio Enabled Vehicular Ad Hoc Networks: A Review*** **620**

Rajith C. Abeywardana (University of Auckland, New Zealand); Kevin W Sowerby (The University of Auckland, New Zealand); Stevan Mirko Berber (University of Auckland, New Zealand)

Cognitive Radio (CR) technology has emerged as an enabling technology to satisfy the increasing bandwidth demands of Vehicular Ad Hoc Network (VANET) applications. Application of CR technology in vehicular environments is a comparatively new research area and numerous problems still require investigation. This paper reviews existing studies related to spectrum sensing in CR enabled VANETs (CR-VANETs). It also provides an overview of existing vehicular communication standards, vehicular channels properties, sensing mechanisms in CR-VANETs and the challenges pertinent to spectrum sensing in vehicular environments. This paper also aims to identify the open issues of spectrum sensing in VANETs and discusses implications for future research in this area.

D2S3-3.6 2:45 ***Low Rank Matrix Estimation Using Robust Principal Component Analysis on FPGA*** **626**

Manupa Karunaratne and Jayathu Samarawickrama (University of Moratuwa, Sri Lanka)

This paper presents a performance optimized FPGA based design for low rank matrix estimation using robust principal component analysis. The system is constructed using mesh connected processor array for singular value decomposition and specialized architectures for merge sort and matrix multiplication for re-composition of the matrix which is computed iteratively. There are no prior implementations of Robust PCA on FPGA and this work presents at least a 50 times performance increment upto 2048 × 2048 matrices, compared to a Matlab implementation running on Core i7-3610QM, 2.3 GHz processor with 8GB RAM.

3:00 PM - 3:15 PM

D2-Tea Break-2: Tea Break

3:15 PM - 4:45 PM

D2S4-1: Online session (virtual presentations)

Room: Salon Jasmine
Chairs: A. M. Harsha S. Abeykoon (University of Moratuwa, Sri Lanka), A. G. Buddhika P. Jayasekara (University of Moratuwa, Sri Lanka)

D2S4-1.1 3:15 ***Efficient Object Classification Using Multiple Views in Manufacturing Environments*** **632**

Kyle Doerr and Jagath Samarabandu (University of Western Ontario, Canada)

In this paper we present a framework for rapid object classification that uses multiple views to classify visually similar automotive parts on a conveyor belt. We have constructed a dataset of 25 different manufactured parts consisting of window pillars and guides. These parts vary in size, orientation and luster and are captured from four view points. We are able to achieve a classification rate of 97.4% using our dataset. Using an object localization approach for each view we provide a method that reduces the time it takes to build the visual vocabularies by 36.6%. Our framework shows has an improved accuracy over using single view classification and is fast enough to have practical industrial applications for fine-grained classification of very similar objects. We are able to demonstrate that ORB descriptors provide superior performance and speed over SIFT and SURF descriptors. By harnessing the speed and low computational expense of using ORB features with our framework, we are able to show that our approach has practical industrial applications in improving quality control.

D2S4-1.2 3:30 ***Improving Multi-View Image Classification Using Higher Order Information and Triangulation Embedding*** **637**

Kyle Doerr and Jagath Samarabandu (University of Western Ontario, Canada)

In this paper we take a look at extensions of the Bag of Words model developed within the last few years. Namely the aggregation of vector residuals known as VLAD encodings and Fisher kernels and assess their performance for the classification task using multiple views. We also take a look at the triangular embedding strategy for classification in the compression domain. Our work focuses on using the binary descriptor known as ORB. We are also able to show that triangular embedding is extremely fast and can provide the best performance without direct spatial encoding on the images themselves and we also demonstrate a novel approach to improve the triangulation accuracy that is less prone to overfitting than the traditional approach. We are able to show that higher order information provides improved performance in the multiple view setting. We finally take a look at the use of multiple view classification for fast image classification with a variable number of views and that our approach using a modified triangular embedding can overcome information loss and be used real-time.

D2S4-1.3 3:45 ***An Information Theoretic Similarity Measure for Unified Multimedia Document Retrieval*** **644**

Pushpalatha K (National Institute of Technology Karnataka, India); Ananthanarayana Vs (National Institute of Technlogy Karnataka, India)

Due to the rapid evolution in multimedia technology, the information rich multimedia data have been growing at a phenomenal rate, which demands the necessity for sophisticated multimedia knowledge discovery systems. Multimedia document is a collection of semantically related multimedia data. Because of the distinct characteristics of multimedia data, each type of data requires a distinct type of processing and knowledge discovery methods to extract the knowledge from the multimedia document. Individual processing and analyzing each type of multimedia data is a tedious and complex task. Instead, it will be more advantageous if multimodal objects are represented in a unimodal domain, such that the similar processing and knowledge discovery methods can be used. In this paper, a domain converting method is proposed to represent the media objects in a frequency domain such that the multimedia document of multimodal objects is represented as multimedia document of signal objects. To find the similarity between the multimedia documents a similarity measure based on information theory is proposed. The proposed similarity measure is evaluated by the precision-recall rate of the multimedia document retrieval. The proposed system presents the multimodal data in a unimodal representation and applies the proposed similarity measure in order to achieve the better document retrieval rate.

D2S4-1.4 4:00 ***Enhanced WiMAX SAR System Equipped with Multiple Modes*** **650**

Kai Liu (University of Western Ontario, Canada); Xianbin Wang (The University of Western Ontario, Canada); Jagath Samarabandu and Auon Muhammad Akhtar (University of Western Ontario, Canada)

Widespread use of WiMAX systems has lowered the cost of radio units significantly. We previously proposed a low cost single-mode Synthetic Aperture Radar (SAR) system, which took advantage of these low-costWiMAX transceiver units. However, the imaging swath of this system was limited due to the short length of the cyclic prefix (CP) of WiMAX. In this paper, we propose a multi-mode WiMAX SAR to overcome this limitation. Specifically, we first propose the design of a scan-mode WiMAX SAR, which significantly expands the slant range swath for surveillance and imaging applications. After that, spotlight and squint-mode WiMAX SAR are also proposed to enhance imaging quality. Finally, a windowing scheme on reference data at the receiver is proposed to reduce ghost images in the range of direction. The validity of proposed design is confirmed through detailed simulation results.

D2S4-1.5 4:15 ***Probabilistic Voltage Stability Analysis of Wind Farm Integrated Power Grid*** **656**

Man Wang (NanJing Institute of Technology, P.R. China); Chen-dong Qiu (Jiang Su Communications Planning and Design Institute Co., Ltd., P.R. China)

Because of the environment issue and energy crisis, wind power is experiencing a rapid development in the world. Unfortunately it also brings increasing voltage stability problems for the reason that its output is stochastic and intermittent. This paper addresses power flow models of fix speed induction generators (FSIG) and doubly-fed induction generators (DFIG) which involve generator's slip, and applies them into probabilistic power flow computation. A novel voltage stability sensitivity index considering wind generator's slip is proposed subsequently, which takes into account the wind power's randomness. IEEE39 bus-system including FSIG and DFIG separately is taken as testing example to verify the effectiveness of the proposed models and voltage stability index , then the paper compares the impacts of two different induction generators on system voltage stability.

Additional Paper

Accelerating Rabin Karp on a Graphics Processing Unit (GPU) Using Compute Unified Device Architecture (CUDA) **663**

Nayomi Dayarathne (University of Peradeniya); Roshan Ragel (University of Peradeniya)

String matching or pattern matching algorithms are used in various applications. They are used to find the occurrences of a pattern in a given text or a pool of strings. They are widely used in text editors in computing machines, database queries, bio-informatics, chem-informatics, search engines and many more applications. String matching algorithms can be of two ways: single pattern matching and multiple pattern matching. Rabin Karp is a string searching algorithm that can act in both ways. Since these algorithms are working on large pool of data, achieving higher throughput on the implementation of the algorithm has always been a major concern. Parallel implementation of such algorithms can achieve the concerned objective. Parallelism could be achieved easily with the rapid development of GPU architectures. In this research, Rabin Karp algorithm is implemented in CUDA C. We have compared CUDA implementation of this algorithm against both its serial CPU implementation and parallel Pthread implementation on multi-core CPUs. Eventually, using the empirical results, we could conclude that the CUDA C implementation of Rabin Karp on the GPU can achieve much high throughput for a large pool of data in string matching.

Wednesday, December 24

7:00 AM - 8:00 PM

Conference Trip

Schedule of the post conference tour

6.30 AM – 6.45 AM	Gathering at the Lobby
6.45 AM	Leave the hotel
8.30 AM – 9.00 AM	Breakfast
9.00 AM – 9.15 AM	Morning at beach
9.30 AM	Visit the turtle conservation project
10.30 AM – 12.30 PM	Madu ganga boat ride
12.30 PM – 1.00 PM	Visit the mask museum - Ambalangoda
1.30 PM	Lunch
2.00 PM	Visit the coral gardens - glass bottom boat ride
4.00 PM	Tea at Galle fort
6.30 PM	Leave the Galle fort
8.30 PM	Arrive at Hotel Galadari