Electrical and Electronic Engineering Research and Project Symposium (EEERaPS) 2018

Undergraduate Research Findings

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Faculty of Engineering
Unviersity of Peradeniya

Content

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Department of Electrical and Electronic Engineering
Faculty of Engineering, University of Peradeniya

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Message from the Head of the Department

The Department of Electrical and Electronic Engineering (DEEE) of the University of Peradeniya (UOP) is the pioneering centre for teaching and research on Electrical and Electronic Engineering in Sri Lanka. UoP is recognized as the number one ranked University in Sri Lanka according to Webometric ranking. The DEEE has a team of world class academics and researchers, a group of outstanding student community, and a strong national and international academic and industrial collaborators. With the culture created since 1960s and progressed over the years, the DEEE, at present, produces 100 graduates annually who can face challenges in almost all disciplines in Electrical and Electronic Engineering, covering the fields of communication and information engineering, Electronics, instrumentation and Biomedical engineering, Robotics, automation and control engineering, power, energy systems ad high voltage engineering.

The DEEE proudly presents its Undergraduate research findings parallel to the events of opening of Wilfred P Jayasekara High Voltage Laboratory and the Electrical and Electronic Engineering Research and Project Symposium (EEERaPS 2018). This publication mainly highlights the capabilities and achievements of undergraduates in the resarch culture. I hope this publication will help you to be informed about our students' research capabilities. We invite and encourage you to strengthen your ties with us and to support the students from the DEEE.

Prof. Manjula Fernando

Message from the Undergraduate Project Coordinators

It is a pleasure bringing to light the booklet on undergraduate project findings at the 5th annual research symposium of the Department of Electrical and Electronic Engineering, University of Peradeniya. The students of the department are engaged in project activities pertaining to the research requirement stipulated under the curriculum. This module fulfills the requirement set out by the Washington Accord to bring global recognition to the degree program.

The project activities inevitably expose the students to the discovery process, time and budget planning and enhanced presentation skills. Most importantly, the students learn how to work in a group and behave responsibly on the assigned tasks. The importance of thorough grasping of fundamentals are made clear to them through projects promoting the process of lifelong learning.

The research findings in the booklet covers a wide spectrum of topics of current interest. We hope it would be useful to the reader.

We would like to take this opportunity to thank the staff for their hard work, commitment, and guidance given towards productive research in the field of Electrical and Electronic Engineering.

Dr. S. G. Abeyratne

Prof. J. B. Ekanayake

Message from the EEES Senior Treasurer

It is my pleasure and privilege to send this message to the DEEE Annual Report 2018. The Electrical and Electronic Engineering Society (EEES) comprises of nearly three hundred undergraduate student members in their second, third and final years of study. The EEES continues to play an active role in promoting creativity, innovation, entrepreneurial and leadership skills with the aim of developing students to hold leading positions in the industry, government and academia. To achieve these goals, EEES organizes a number of academic and professional development events every year such as presentations and workshops conducted by local and international researchers and leading professionals from the industry. The alumni network too maintains a strong relationship with the EEES by serving as a valuable resource and mentoring the undergraduates in many occasions.

I would also like to take this opportunity to congratulate our students those who won awards and received commendations at various local and international competitions held in 2018. I wish every success and good luck to our current final year students those who will graduate in early 2019. I am sure that some of you will venture out into the industry to secure top positions while others to continue with their postgraduate studies and research in world renowned universities across the globe.

I look forward to work with the EEES committee and guide all future endeavours in the future.

Dr. S. A. H. A. Suraweera

DSP Chanelizer Implementation

D.M.C.D. B. Dasanayaka[1], R.M.N. Dayananda[2]
Supervised by: Dr. Aruna Gunawardhena[3] and Mr. Sanka Priyarathne[4]

[1]chirathd@yahoo.com, [2]nipundayananda@gmail.com, [3]aruna@ee.pdn.ac.lk,
[4]sanka@solinnov.com.au

[1-3]University of Peradeniya
[4]Solinnove Australia

Channelizers are widely used in modern digital communication systems. Advanced uniform multi-rate channelization has been theoretically proved to be capable of reducing the computational load, with better performance. In this project a chanelizer with polyphase architecture is designed and Register Transfer Level (RTL) level simulation is done using Vivado HLS (High Level Synthesis) tool for comprehensive evaluation of resource usage, performance, and frequency response.

A Quadrature Phase Shift Key (QPSK) modulated and sampled data sequence was used as the input signal. Outputs of the channels and performances of the chanelizer were observed. It was observed that the latency is lesser when using fixed point representation for numerical values than when using floating point representation. Pipelining was also used in order to increase the performance of the chanelizer. Chanelizer architecture was also implemented using C language to compare the outputs of RTL simulation and software simulation and to verify the results.

Design of an Interferometric Radar for Disaster Mitigation

D.M.T.M. Dissanayake[1], J.A.M.S. Jayasuriya[2], A.C.L. Jayathilake[3]
Supervised by: Dr. Aruna Gunawardhena[4]

[1]thilinamadudissanayakei@gmail.com, [2]jayasuriyamaduwantha@gmail.com,
[3]acljaya@gmail.com, [4]aruna@ee.pdn.ac.lk

[1-4]University of Peradeniya

The constructions such as tall buildings, dams etc. and the geographical planes undergo invisible deflections and drifts. Massive disasters could be predicted or even be prevented if mm level deflections could be measured and analyzed. In this project an interferometric radar with the capability of measuring mm level deflection of an object within a range of one kilometer is designed.

This project involves an optimized design of a Frequency Modulated Continuous Wave radar system (FMCW) radar with a centre frequency of 5.8 GHz and a bandwidth of 100 MHz. System level design, simulation, and the layout design of the radar system was done using AWR Microwave Office Design Environment. In this design a 2875 - 2925 MHz signal is generated by a VCO and its frequency is doubled using a frequency multiplier. The required transmitting signal is then split and fed to a mixer and the transmitter antenna (with RF amplification and proper filtering). The received signal frequency is mixed with a sample of the transmitted signal and the IF output is low pass filtered. The mm-level deflections are measured using the phase difference of the signals received at difference times. A/D conversion and the relevant calculations are done using an Arduino board.

Photovoltaic System for a Small Electric Vehicle as a Range Extender

[1]K.M.S. Dayasiri and [2]P.P.L.S. Karunasena
Supervised by: [3]Dr. P.J. Binduhewa

[1]dayazz055@gmail.com, [2]lakmalsajith1712@gmail.com, [3]prabathb@ee.pdn.ac.lk

[1-3]University of Peradeniya

Electric vehicles are becoming popular because they are environmentally friendly compared to combustion engines. Driving range of an Electric vehicle depends on the capacity of Battery. Integrating a PV system on roof of an Electric Vehicle can extend the driving range, as battery can be charged while driving. This project aims to design and implement a battery charger using a vehicle roof mounted PV panel as a range extender for an Electric Three-wheeler.

The proposed Electric Three-wheeler consists of hybrid storage in the form of battery and super capacitor. The storage units are connected to a dc-link through bi-directional dc-dc converter each. There are two options to connect the PV power to the battery or dc-link. Connecting the output of the panel to the battery is efficient when the vehicle is stationary. Also, PV output can be connected to the dc-link directly when vehicle is on the move. A basic boost converter was used for two cases. The power electronic system for the two options were simulated using PSCAD software. The open-loop and closed-loop operations were simulated. The results verified the operation. The boost converter was implemented in hardware and verified the open-loop operation. The closed-loop operation of the converter to be verified.

Multiport Distribution Board

A.S.F. Sajeera[1], L.D. 002Suraweera[2], T.C.J.S.B.B. Thennahena[3]
Supervised by: Dr. P.J. Bindhuhewa[4], Prof. J.B. Ekanayake[5]

[1]sajeerafathima94@gmail.com, [2]ldsuraweera1994@gmail.com,
[3]chiranthathennahena1@gmail.com, [4]prabathb@ee.pdn.ac.lk, [5]jbe@ee.pdn.ac.lk

[1-5]University of Peradeniya

The distributed grid connected PV systems are gradually increasing in Sri Lanka and around the globe and will continue in the future. With the rapid development of energy storage techniques and dc loads, a domestic distribution should comprise of dc and ac multi-ports to integrate loads and sources in the forms of ac and dc. Such an interface would increase the efficiency by reducing the number of conversion stages. The proposed system is a design of a power electronic interface of a multi-port distribution board with controllers which enables to realize the above functionalities. Majority of the utility side will be handled by the PV panel and it can supply other two units as well.

This multiport power electronic interface combines the grid and a photovoltaic system along with an enhanced storage unit as power sources. The design methodology, component selection, open loop and closed loop simulation results of the designed power electronic converters and their controllers using PSCADTM / EMTDCTM have obtained and presented. Each source is connected to the dc link via controllers. Maximum Power Point Tracking algorithm is devised to get maximum output from PV panel. Inner current and output voltage PI controllers were used in bidirectional dc dc converter. For the inverter part which is capable of bidirectional power supply, one controller was designed to control the inductor current and it is designed using single phase dq frame analysis. All three converters were implemented and verified the rated power operation. The closed loop controller implementation is presently investigating.

Application of Signal Processing Techniques for Buried Target Detection from a GPR

E.G.S.N.G. Gamage[1], J.H.S.P. Karunarathna[2], M.P.R. Senadhira[3]
Supervised by: Prof. D.N. Uduwawala[4], Dr. R. Godaliyadda[5],
Dr. P.M. B. Ekanayake[6]

[1]supungamage001@gmail.com, [2]supun93.sp@gmail.com, [3]prabothsenadhira@gmail.com,
[4]disala@ee.pdn.ac.lk, [5]roshangodaliyadda777@gmail.com, [6]mpb.ekanayake@gmail.com

[1-6]University of Peradeniya

Ground penetrating radar (GPR) Technology has developed drastically within last few decades with the incorporation of advanced signal processing techniques. GPR systems are increasingly being used for the detection and location of buried objects such as land mines, water pipes and water tables as a nondestructive identification method. In principle, the GPR can be viewed as composed of a central unit, a transmitting antenna, a receiving antenna and a computer. The central unit generates an electromagnetic signal that is radiated in to the soil by the transmitting antenna. The signal radiates in all directions, but most of the energy is confined to the main lobe of the antenna.. The electromagnetic waves get scattered when they come across any buried discontinuity in electrical properties such as permittivity. The signal received by the receiving antenna contains direct coupling from the transmitter, ground surface reflections, scattered signals from the target and other soil inhomogeneity. The application of signal processing techniques helps discriminate the target signal from other unwanted signals known as clutter to form the image of the buried object. The developed stepped frequency prototype GPR has a pair of resistor-loaded bow-tie antennas enclosed in rectangular metal cavities. This is used to detect metal and plastic pipes buried in sand. The stepped frequency signals are generated by the network analyzer in the range 50 MHz-2 GHz. The GPR measures S21 parameter in the network

analyzer. The corresponding time domain response is derived by taking the inverse Fourier transform of S21.

Frequency domain responses collected for a particular position of the buried target using Ground Penetrating Radar antenna is processed to obtain B-scan images which are used in the identification process. The position of the object is determined by the selection of the maximum value of the amplitude matrix of the B-scan image and setting a threshold value. The amplitude values below the threshold value are filtered out and plotted to map the buried object below the subsurface. Accurate region of the buried object can be obtained by taking several readings. And moreover, the depth of the buried object is determined using delayed time estimation method where the frequency domain data collected are converted to time domain to plot a graph of amplitude of the received signal vs. time. When a target is detected by the antenna, a narrower signal with high amplitude is plotted at the relevant time. The depth of the buried object from the subsurface is calculated using the time and the characteristics of the medium. Furthermore, Envelope of the time domain response is used to obtain the approximate cross section view of the buried target.

Design and Fabrication of a Doppler Radar using a Micro strip Planar Antenna Array

R.A.P.M. Ranathunga[1], W.A.L.H. Wickramanayake[2], P.M.S.L Wickramarathne[3]
Supervised by: Prof. D.N. Uduwawala[4], Dr. Aruna Gunawardhana[5]

[1]pamodimethmini@gmail.com, [2]lashaniwickramanayake@gmail.com,
[3]saumyalakmali999@gmail.com, [4]disala@ee.pdn.ac.lk, [5]aruna@ee.pdn.ac.lk

[1-5]University of Peradeniya

Microstrip antennas play a very important role in the today's wireless communication systems such as in military, satellite communication, 5G technology etc. Low profile, easiness of design and fabricate have made it ideal for most applications. In this project a 4x4 microstrip planar array antenna is designed and analyzed using the Transmission line model which gives a good physical insight. Two such identical antennas are used as the transmitting and receiving antennas in the Doppler radar circuit. The radar is designed to detect the speed of a vehicle moving at 50 kmph- 150 kmph within a range of 50- 200m.

Design and simulation of the patch antenna was done using HFSS software at 10.5 GHz. Feeder circuit of the radar was designed and simulated using AWR software by selecting the components which give 10 mW of transmitting power to the antenna. 5250 MHz frequency is generated by a VCO and is doubled using a frequency multiplier to the resonance frequency of the antenna, 10.5 GHz. A splitter was designed in AWR to split this signal to transmitter and to mixer. At the mixer, received signal is mixed with the transmitted signal. The resulting IF signal carries Doppler information. In order to measure the Doppler shift, an Arduino board is used and the speed is calculated. Speed will be displayed on a LCD display.

Fetal Movement and Heartbeat Analysis for Condition Monitoring

S.A.Y. Abeywardhana[1], H.A.A. Subhashini[2], W.A.W.S. Wasalaarachchi[3]
Supervised by: Dr. Janaka Wijayakulasooriya[4], Dr. R. Godaliyadda[5]

[1]sayabey@gmail.com, [2]anupamasubashini@gmail.com, [3]wishmi.wasala@eng.pdn.ac.lk,
[4]jan@ee.pdn.ac.lk, [5]roshangodaliyadda777@gmail.com

[1-5]University of Peradeniya

Fetal movement patterns are a measurement of fetal well-being. Therefore, it is important to ascertain fetal movements to avoid fetal morbidity and death. In this research, accelerometer data taken from pregnant women were analyzed to obtain fetal movement patterns. Identification of fetal movements from the accelerometer data is arduous due to the presence of mother's artifacts. Hence, time domain and frequency domain analysis were utilized to separate fetal movements from other artifacts.

A device was implemented to collect accelerometer data using a non-invasive passive sensor to reduce the impact on the fetus and the mother. In this research, algorithms were generated based on eigenvalue and eigenvector analysis of Auto correlation matrix, Dynamic time warping, spectral clustering and Non negative matrix factorization. A method was proposed to identify fetal movements for certain conditions. In this method, fetal movements were separated hierarchically by considering the Eigenvalues and Eigenvectors of the auto correlation matrix in the time domain. To generate a general algorithm, Dynamic time warping, spectral clustering and Non negative matrix factorization were used. This method could be used to automate the fetal movement counting device.

Affective Signal Processing for Facial and Expression Recognition

D. Micky Poul[1], R. Vinojan[2]
Supervised by: G. M. R. I. Godaliyadda[3], M. P. B. Ekanayake[4], H.M.V.R. Herath[5]

[1]mickypoulduke@gmail.com, [2]srvinojan.vr@gmail.com, [3]roshangodaliyadda777@gmail.com, [4]mpb.ekanayake@ee.pdn.ac.lk, [5]vijitha@ee.pdn.ac.lk

[1-5]University of Peradeniya

The face is a preferred biometric modality in various applications due to its ease of access and low complexity in nature. Face recognition is an identification system that uses facial characteristics of a person to identify his or her identity. The deformations that occur in the face during facial expressions significantly degrade the performance of the face recognition systems. It is a critical issue in many applications such as forensic and surveillance as it is easy to spoof or fake the system using facial expression. This project proposes a simple and effective method that can be integrated into any face and expression recognition system to improve the overall recognition accuracy even under limitations in training samples.

In this approach, the neutral component of the expressive image is estimated utilizing prior information obtained from different subjects under the same expression. Through analysing the deformation process of occurring due to an expression on a neutral face a nullification process is developed to convert an expressive image to a neutral face. In order to justify the usage of generic expression information on different subjects, an alignment strategy is employed for each expression on a specific expression template, and the images are warped to their corresponding expression template. After negating the facial expression from the expressive images, principal component analysis (PCA) is applied to reduce the dimension and cosine similarity matching is used for classification. The experimental results on Extended Cohn-Kanade database exhibit the effectiveness of the proposed method even when there is a single training sample per class as is available in the database.

Smart Surveillance System for Child and Elderly Care

M.M.N.U.P. Marasingha[1], W.T. Ruwanga[2], I.N. Manapperuma[3]
Supervised by: Dr. S.A.H.A. Suraweera[4], Dr. G.M.R.I. Godaliyadda[5], Dr. M.P.B. Ekanayake[6]

[1]udithamm1994@gmail.com, [2]thanushiwithanage@gmail.com, [3]ineshinisansala00gmail.com, [4]himal@ee.pdn.ac.lk, [5]roshangodaliyadda777@gmail.com, [6]mpb.ekanayake@ee.pdn.ac.lk

[1-6]University of Peradeniya

According to medical research, a significant percentage of deaths occurring among elderly population happen due to various kinds of falls. In order to prevent such adverse scenarios, in this project a sensory model combined with video surveillance system was implemented on Matlab software together with image processing and machine learning techniques.

Initially, the accelerometer and gyroscope readings extracted from the wearable sensor device were classified using basic signal features while the results were used to accurately identify specific daily activities such as sitting, standing, falling on different sides, walking upstairs or downstairs and fast to slow walking. Further in order to analyze the walking trajectories of persons, videos were taken from a fixed camera and using blob analysis the centroids of the moving persons were tracked. Using dynamic time warping as a distance measuring technique, obtained trajectories were compared to track several cases including walking pattern anomalies. A spectral clustering algorithm was used to cluster the trajectories into groups using cluster signatures and to identify walking behaviors. Further, the techniques of overlapping mitigation, perspective transformation and optical flow were used to analyze group dynamics among people. The implemented solutions can be used to monitor elderly as well as child walking behaviors.

Underwater Visible Light Communications Under Turbulent Condition

M.I.M.M. Ismail[1], M.J.M. Fazlan[2], D.D.K.R.W. Dandeniya[3]
Supervised by: Dr. S.A.H.A. Suraweera[4], Dr. G.M.R.I. Godaliyadda[5], Dr. M.P.B. Ekanayake[6]

[1]majithismail@eng.pdn.ac.lk, [2]fazlan.mohamed@eng.pdn.ac.lk, [3]kanishka.d@eng.pdn.ac.lk, [4]himal@ee.pdn.ac.lk, [5]roshangodaliyadda777@gmail.com, [6]mpb.ekanayake@ee.pdn.ac.lk

[1-6]University of Peradeniya

Underwater communication has become a major topic of research interest in the recent past due to many emerging applications. Visible light is used to implement point-to-point and multipoint underwater communication channels. A underwater visible light communication (VLC) system consists of light emitting diodes (LEDs) at the transmitter and photo diodes at the receiver. This project was designed so as to implement a new underwater visible light multiple input/output communication system in which transmitter is made of LEDs and the receiver is a camera with a control mechanism to align them.

Data is transmitted from a submerged system to a floating receiver using a line of sight scenario. Data were encoded into multiple input streams at the transmitter. At the receiver, the camera captures the continuous LED pattern variations in video format, and it is then analyzed frame by frame to decode the data. LED patterns were recognized and decoded using algorithms trained to identify the features in the image. Furthermore, the alignment controller with two degrees of freedom is designed to reduce bit errors due to misalignment of transmitter and receiver. The objective of this system is to achieve a superior bit error rate performance at short to medium distances. Hence this underwater VLC system can be used in situations where reliability is of priority in underwater communication.

The Correlation between Cloud Cover and PV Output

W.P.P. Fernando[1], R.K.H. Ishara[2], T.H.M. Wasana[3]
Supervised by: Prof. Janaka Ekanayake[4], Dr. Roshan Godaliyadda[5], Dr. Parakrama Ekanayake[6]

[1]pamudika07@gmail.com, [2]hiruniishara123@gmail.com, [3]vasana1993@gmail.com, [4]jbe@ee.pdn.ac.lk, [5]roshangodaliyadda777@gmail.com, [6]mpb.ekanayake@ee.pdn.ac.lk

[1-6]University of Peradeniya

The contribution of solar Photovoltaic (PV) power generation to the electric power system has seen a significant growth in recent years. It has many advantages like low environmental impact and zero fuel costs compared with the conventional energy sources. The output of a PV panel will vary on several factors such as the solar radiation, status of the PV panels (aging, cleanliness) and also on the ambient temperature of the site.

The main factor affecting the PV output is the solar irradiance but the amount of solar radiation that reaches the ground will vary with the intermittency of cloud cover. A technique to correlate the solar irradiance with the image properties of the ground-based sky images was identified. A sequence of whole sky images were obtained and were used to analyze the image properties and prominent ratios based on RGB, YCbCr, HSI intensity values which vary significantly with the solar irradiance. A database was created using prominent features and was analyzed using PCA (Principle Component Analysis). Two prominent features were identified and were used to categorize the database into 3 main irradiance levels. The identified correlation can be further developed to predict the PV output from the ground-based sky images captured.

Development of a Fault Current Indicator

W.C.N.G. Fonseka[1], W.G.M.S. Weerasinghe[2]
Supervised by: Dr. Lilantha Samaranayake[3], Prof. J.B. Ekanayake[4]

[1]nuwanfonseka@eng.pdn.ac.lk, [2]menuka615@gmail.com,
[3]lilantha.samaranayake@gmail.com, [4]Jbe@pdn.ac.lk

University of Peradeniya

The aims of this project are calculating the real-time loadability of a transmission line, developing a PCB based Rogowski coil for current measurements and developing a communication method to take data into a computer interface. The Rogowski coil allows the identification of any fault in the line by checking the current through it against a set limit. The Rogowski coil will not saturate under faulty conditions because of the absence of the ferromagnetic core. It has proved that the derivative of the conductor current is proportional to the output voltage of the Rogowski coil. However, as the output voltage is very small (in μv range), a specially designed low noise amplifier circuit has been used. This device enables to improve the reliability of the distribution line and quality of the supply.

In the case of loadability calculation, thermal equilibrium method was used. In this method, real-time conductor temperature and perpendicular wind speed have been used as inputs to the system. These inputs were sent to a mobile system using radio frequency signals. Then the mobile system processes that data into desired outputs using Arduino based processor (AtTmega328P) and display on an LCD display on the mobile system.

Automated Recognition of Partial Discharge Patterns in Stator Windings of Electrical Generators

A.S.D. Athukorala[1], W.A.V.S. Kumari[2], W.K.M.M. Wickramasingha[3]
Supervised by: Dr. Janaka Wijayakulasooriya[4], Dr. Sarath Kumara[5], Prof.Manjula Fernando[6]

[1]asdathukorala72@gmail.com, [2]vayanisaranga92@gmail.com, [3]monalimanjula15@gmail.com, [4]jan@ee.pdn.ac.lk, [5]sarath@ee.pdn.ac.lk, [6]manjula@ee.pdn.ac.lk

[1-6]University of Peradeniya

Partial Discharge (PD) occurs in stator insulation system of rotating machines, where local electric field stress exceeds the local electrical strength. PD can damage insulation materials in power transformer and generator windings leading to their eventual failure and costly outages. Therefore, it is important to recognize the PD source, find it, and eliminate it when necessary. PD measurements allow localized weak points of the insulation to be identified.

Electromagnetic radiation near a stator winding of a generator was measured and analyzed to find the PD pulses. Then the signatures are analyzed to identify the PD types that are harmful for insulation systems. PD signals were analyzed based on unsupervised pattern recognition techniques (multi PD sources clustering). Pulses in PD signals caused due to inevitably emerged noises and disturbances in the generators other than PD pulses, were initially suppressed through several methods including filtering. Then, PD pattern recognition stage which consists of two parts, feature extraction from de-noised data using time frequency domain techniques such as Discrete Wavelet Transform (DWT). Then pattern recognition of the respective PD source was done by using statistical analysis method. Dimensionality of the feature vector was reduced using Principal Components Analysis (PCA) for clustering. In addition, another set of features were generated using kurtosis and standard deviation then clustered using self-organizing map (SOM). The research has found that it gives more accuracy when using statistical data than using DWT.

Design of a Low Fidelity Polar Coodinate Based CNC System

A.M.D. Aththanayake[1], P.H.D.G. Dhanushka[2], N.P.L.T. Jayadewa[3]
Supervised by: Dr. Janaka Wijayakulasooriya[4]

[1]dilshanaththanayake15784@gmail.com, [2]damithgdhanushka@gmail.com,
[3]tharaka.jayadewa@gmail.com, [4]jan@ee.pdn.ac.lk

[1-5]University of Peradeniya

Current industrial X-Y plotter cutters have performance issues in cutting out high precision shapes. Mathematical models for these plotter cutters are not publicly available and thus the parameters critical to cut quality are not well understood. This project developed a dynamic, electromechanical model for the gantry arm and media feed using first principles. These models were independently simulated and experimentally verified. In order to verify the effectiveness of the individual models, they are combined with a control system and trajectory generation algorithm.

Initially a trajectory generation algorithm was developed, and it was simulated using MATLAB. After completing the simulations, the hardware part was designed. In the hardware part, initially R-axis was built using thread bar mechanism. Then Angle axis was designed using gear wheel mechanism and pen up-down mechanism was also included. The overall system is run by using two microcontrollers and they were synchronized. PID controllers were used for changing the speed of the machine After finishing the hardware part of the project, few test runs were done. In testing the PWM variation with time was tested for various PID controllers. In the latter part of the project, an user interface was created to give input coordinates directly, instead of giving the coordinates as an array. Finally, the speed and the accuracy was increased to a precise level as expected in the beginning of the project.

Smart Load Scheduling for Community Renewable Energy

I.U. Muthunaike, L.R. Senarathne, P.R. Senevirathna
Supervised by: Dr. Janaka Wijayakulasooriya[4]

[1]ilumuthu@gmail.com, [2]lakminisenarathne93@gmail.com, [3]probodi.ruwanthika@gmail.com, [4]jan@ee.pdn.ac.lk

[1-5]University of Peradeniya

Demand Side Management (DSM) and Dynamic Electricity Pricing encourage consumers to schedule the appliances in an optimal way. Simultaneously it reduces the residential electricity cost and the peak demand. The use of Intelligent Decision Support Systems has become vital for load scheduling which supports consumers to respond to dynamic tariff environment.

This research studies the DSM strategies for residential customers, where customer provides the desired operation of each shiftable and uninterruptable electricity appliance as time limits and estimation of future real time prices if the utility has not released the prices for the desired day to obtain the load schedule. Next, the optimal scheduling of residential appliances in a community is carried out under dynamic pricing and dynamic cable rating environment to increase the profit of the community. There, the community can make a revenue by selling the excess renewable energy to the utility. The price predictor predicts future tariff referring history tariff data using Multiple Linear Regression and Markov Chains. For the load scheduling, standard methods (Exact method, Genetic algorithm, Mixed Integer Linear Programming) are applied and two novel approaches, namely Vacant Power Method and Prior Ranking Method were proposed. The price predictor accuracy is analyzed using two data sets: continuous tariff data and discrete tariff data.

Remote EV Battery State Monitoring for Light Electric Vehicles

K.M.T.B. Gunarathne[1], K.W.M.K.P. Ranasinghe[2], P.A.N.S. Ranasinghe[3]
Supervised by: Dr. Lilantha Samaranayake[4]

[1]thilankagunarathne@eng.pdn.ac.lk, [2]kalpana.ranasinghe@eng.pdn.ac.lk,
[3]niraj.ranasinghe@eng.pdn.ac.lk, [4]lilantha@ee.pdn.ac.lk

[1-4]University of Peradeniya

There is an increasing need for finding a reliable alternative in order to replace gasoline driven vehicles. To cater this need, the electric vehicle (EV) industry is growing rapidly. The EV battery is one of the most critical components in an EV powertrain in determining the range of the vehicle and the state of health (SOH) of the battery itself. Therefore, monitoring the states of the battery such as the SOH, temperature, etc., of the EV is important to the battery company as well as the EV user. In the future, due to limitations in the charging time, it is expected to move towards battery swapping methods to mitigate the high battery charging times.

In this project a setup of two series connected 18Ah, 12V batteries are modelled using Thevenin's equivalent model. MATLABTM is used to model the battery. Power pulse test is conducted offline on the battery and the results are used to calculate the battery parameters. They are the Thevenin's capacitance, the polarization resistance and the open circuit voltage. To estimate the battery states which are the State of Charge (SOC), the SOH and the Thevenin's Voltage in a noisy nonlinear system, an Extended Kalman Filter is implemented using the modelled battery parameters. The measured terminal voltage of the battery is used in this Extended Kalman Filter for the error correction.

Dynamometer Test Bed for Electric Vehicle Experiments

H.W.B Dissanayake[1], P.M.M Gunathilaka[2], G.V.K.S Perera[3]
Supervised by: Dr. Lilantha Samaranayake[4], Prof. J.B. Ekanayake[5], Dr. Prabath J. Binduhewa[6]

[1]harshanadissanayake96@gmail.com, [2]maheshigunathilaka95@gmail.com, [3]keminda1995@gmail.com, [4]lilantha@ee.pdn.ac.lk, [5]jbe@ee.pdn.ac.lk, [6]prabathb@ee.pdn.ac.lk

[1-6]University of Peradeniya

Torque vectoring in electric vehicles with individually actuated in-wheel motors presents the opportunity to implement a wide range of control strategies for controlling vehicle yaw rate to improve vehicle stability and performance. When vehicle gets a bend driver needs to slow down the vehicle to move safely. In order to avoid this problem and maintain higher speed different torque values can be given to different wheels to maintain the stability, which is torque vectoring.

In this project torque vectoring control strategy's effect on a vehicle's dynamic performance is validated and analyzed through use of simulations in Simulink software. MATLAB/Simulink was used to model the test bench and simulate the control scheme for a standard drivecycle. The inputs to this model are the velocity (or angular velocity), slide slip angle, steering angle of the front wheels and the angle of inclination of the road. The user is able to use steering wheel and paddle system as input devices. The graphical user interface gives the user the ability to compare the difference in the performance between a vehicle using torque vectoring and a vehicle not using it.

Brain TumorSegmentation using Deep Learning Algorithms for Magnetic Resonance Imaging

Shanaka Ramesh Gunasekara[1], H.N.T.K. Kaldera[2]
Supervised by: Dr. Maheshi B. Dissanayake[3]

[1]shanakag@eng.pdn.ac.lk, [2]nick9311@gmail.com, [3]maheshid@ee.pdn.ac.lk

[1-3]University of Perdeniya

In this study we consider the problem of fully automated brain tumor classification and segmentation, for Magnetic resonance imaging (MRI) with both glioma and meningioma types of brain tumors. We propose Convolutional Neural Network (CNN), for classification problem and Faster Region -Convolutional Neural Network (Faster R-CNN) based system for segmentation problem with reduce number of computations, and a higher level of accuracy.

This study identifies the region of interest that is either glioma cells or meningioma cells, with higher confidence level, and localizes the tumor on the MRI with the binary tumor mask. Contour detection algorithms are employed to obtain the tumor boundaries for the tumor mask generation. The segmented tumor regions are validated through ground truth analysis and manual observation by a Neurologist. We have used a data set with 218 images as training set, and the systems shows an accuracy of 100% in meningioma and 87.5% in glioma classifications. An average confidence level of 94.6% in segmentation of meningioma tumors and 93.6% in that of glioma tumors is achieved, Further, analysis shows that with the proposed technique it is possible to achieve an average detection accuracy, sensitivity, Dice score and confidence level of 99.81%, 87.72%, 91.14% and 93.6% respectively for glioma segmentation.

Partial Discharge Analyses for Generator Winding Fault Classification

E.M.U.N. Ekanayake[1], H.M.N.P. Herath[2], G.C. Perera[3]
Supervised by: Prof. M.A.R.M Fernando[4], Dr.J.R.S Kumara[5],
Dr. J.V. Wijayakulasooriya[6], Dr. K.M.K.S. Bandara[7]

[1]uth7ekanayake@gmail.com, [2]nalindiherath@gmail.com, [3]gayathri.perera@eng.pdn.ac.lk,
[4]manjula@ee.pdn.ac.lk, [5]sarath@ee.pdn.ac.lk, [6]jan@ee.pdn.ac.lk, [7]kmkssanju@gmail.com

[1-6]University of Peradeniya
[7]Ceylon Electricity Board

Generators, as the main power apparatus, may fail mainly due to failure of their stator winding insulation. When generators are in service, their insulation may get degraded and as a result partial discharges (PD) may occur in the stator winding. The common PD types are slot PD, internal PD, end winding PD and delamination PD. Apart from offline PD testing (e.g.: DC Ramp and Tan delta) online PD measurement will allow the analysis during the normal operation of the machine. But there are issues concerning in electrical interference (noise), volume of data and interpretation.

The motivation to the project is to explore an alternative and less expensive method to de-noise, analyze and identify PDs instead of the expensive current inbuilt PD measuring systems. Raw PD data were taken from 4 synchronous generators in three power plants in Sri Lanka, namely Samanelawewa, Polpitiya and New Laxapana along with the measurements from the inbuilt system. Basic filtering techniques were applied to the raw signal to identify basic features of the PD signal (i.e. frequency of PD). Then the raw signal was filtered using proposed filtering methods based on the variance method, Eigen filtering, and PD modeling. A PD pulse was modeled using Stieglitz McBride algorithm with a combination of functions of four parameters i.e. Main frequency of the PD pulse, Phase angle, Damping Coefficients, and Amplitude and those data were used to find a possibility of a novel PD

classification. The phased resolved partial discharges (PRPD) Patterns were generated from noise filtered data and PD source identification was explored while verifying with the data obtained from the inbuilt system.

Prediction of Domestic Electric Energy Consumption Using Echo State Networks

S.T. Athukorala[1], R.D.W.M.R.S. Wadimuna[2], V.R. Wijesooriya[3]
Supervisors by: Dr. Nalin Harischandra[4], Dr. Janaka Wijayakulasooriya[5]

[1]shamindathushan@gmail.com, [2]roshansriw@gmail.com, [3]vihangaramesh@gmail.com,
[4]nalin@ee.pdn.ac.lk, [5]jan@ee.pdn.ac.lk

[1-5]University of Peradeniya

Rapid growth of world population has a higher impact on electric power consumption. Therefore, effective usage of electric power is an important concern. The power usage is varying throughout the day and the knowledge of such variations is important for efficient consumption. Therefore, we predict the domestic energy consumption of a day using an Echo State Network (ESN), a special recurrent artificial neural network.

The ESNs are easy to implement and fast to train compared to networks that need to be trained by classical, gradient-based training methods. It has been shown that ESNs are suitable for chaotic time series predictions with a comparatively high accuracy. The data set which includes domestic electric energy consumption for a two-year period was obtained from an online database. The data were analyzed according to the day, weeks and seasons. The ESN was implemented and trained using MATLAB ESN toolbox. Parameters of the ESN were systematically varied and the prediction performances, mean squared errors, were compared to obtain the optimum set. The prediction model will be incorporated into a standalone package or application to be used by the end users.

Active Tactile Sensor: Insect Inspired Robotic Antenna

Shanaka Ramesh Gunasekara[1], H.N.T.K. Kaldera[2], M.K.N.K. Kankanamge[3]
Supervised by: Dr. Nalin Harischandra[4], Dr. Lilantha Samaranayake[5]

[1]shanakag@eng.pdn.ac.lk, [2]nick9311@gmail.com, [3]mknkankanamge@gmail.com,
[4]nalin@ee.pdn.ac.lk, [5]lilantha@ee.pdn.ac.lk

[1-5]University of Peradeniya

Many insects and some mammals such as rodents carry actively movable tactile sensors, antennae or whiskers, on their head to explore the near-range space. During locomotion, antenna is involved in orientation, for example in detecting, localizing, probing, and negotiating near range obstacles. A bionic tactile sensor used here is inspired by the antennae of the Indian stick insects.

Vibration based sensor is able to detect an obstacle and its location in three-dimensional space. Since the tactile sensor used here is independent from lighting conditions, the readings will not vary with the illumination conditions. The vibration signals were analyzed in frequency domain using Fast Fourier Transform (FFT) to estimate the distances. In addition, an Artificial Neural Network (ANN) and a Support Vector Machine (SVM) were used for the classification and prediction process. These three prediction techniques were compared in both distance estimation and material classification. When estimating the distances, the accuracy of prediction deteriorates towards the tip of the probe due to the change in vibration modes, which was mathematically analyzed and a new effective solution is proposed to estimate the distance along the full range of the probe.

Brain Computer Interfacing using EEG

R.T. Munasinghe[1], P.D.S. Muthukumarane[2], N.M.S. Silva[3]
Supervisors by: Dr. Ruwan Ranaweera[4], Dr. Janaka Wijayakulasooriya[5]

[1]ruchira450thilan@gamil.com, [2]dhanithsri1234@gamil.com, [3]malinda.silva@eng.pdn.ac.lk, [4]rdbranaweera@ee.pdn.ac.lk, [5]jan@ee.pdn.ac.lk

[1-5]University of Peradeniya

Some Patients are no longer able be to communicate effectively or even interact with the outside world in ways that most of us take for granted. In the most severe cases, tetraplegic or post- stroke patients are literally 'locked in' their bodies, unable to exert any motor control after, for example, a spinal cord injury or a brainstem stroke, requiring alternative methods of communication control. But we suggest that, in the near future, their brains may offer them a way out. Non-invasive. Electroencephalogram (EEG) – based brain computer interface (BCI) can be characterized by the technique used to measure brain activity and by the way that different brain signals are translated into commands that control an effector (e.g. controlling a computer cursor for word processing and accessing the internet). This review focuses on the brain basic concept of EEG-based BCI.

The project was mainly branched into three major parts namely, the hardware (Development of an active electrode), Classification of visually evoked potential signals and the development of the Application programming Interface (API). As a novel idea the electrodes are taking a major role where the signal is extracted, filtered and then converted into digital signal itself on the electrode before transmitting to the main controller via I2C protocol which makes less interferences. The data acquisition is done using the commercially available BioRadio150 device by cleveMed. The collected EEG signals were then classified using various statistical analysis methods in order to have a dominant feature.

Using the statistical features calculated for the decomposed signal coefficients using wavelet transformation, the classification accuracy of 79.9% was obtained.

Ayurvedic Naadi Measurement and Diagnostic System

H.E.J. Umasha[1], K.K.R. Nisansala[2], H.D.F.R. Pulle[3]
Supervised by: Dr. Ruwan Ranaweera[4], Dr. Janaka Wijayakulasooriya[5]

[1]umashajayani@gmail.com, [2]nisansalaruvi@gmail.com, [3]hashdayanara@gmail.com,
[4]rdbranaweera@ee.pdn.ac.lk, [5]jan@ee.pdn.ac.lk

[1-5]University of Peradeniya

Ayurvedic naadi pariksha is an ancient technique to diagnose diseases by feeling pulsation of radial artery in the wrist of the patient using index, middle and ring fingers of the physician. In this pro-ject a non-invasive device was designed to acquire three naadi pulses, Vata, Pita and Kapha. Inten-tion of this project is to analyze the scientific basis behind Ayurvedic naadi pariksha in distinguish-ing age and gender and to diagnose diabetic patients based on this method.

A Naadi acquiring device was designed to acquire pulse signals using Piezo-electric sensors along with a NI USB6009 DAQ interfaced with LabVIEW for data acquisition. Pulse signals from 70 volunteers under age 30 and above 50 were acquired in both genders for training and testing. The results concluded that, the gender can be distinguished with an accuracy of 83.33% for the group below 30 and 66.67% for the group above 50, while males with 83.33% and females with 66.66% accuracy and diabetic with 85.71% accuracy. The results further proved that the device have efficacy and consistency.

Lightning Effect Analyses on Heritage Giant Stupas

Aruni Bandara[1], Chalani Rathnayake[2], Dulanjalee Ambepitiya[3]
Supervised by: Prof. Manjula Fernando[4], Dr. Sarath Kumara[5], Prof. K.A.S. Susantha[6], Dr. D.K. Jayaratne[7]

[1]bandara.aruni@gmail.com, [2]chalani1000@gmail.com, [3]dulanjalee.93@gmail.com, [4]manjula@ee.pdn.ac.lk, [5]sarath@ee.pdn.ac.lk, [6]samans@pdn.ac, [7]dkjayaratne2011@gmail.com

[1-7]University of Peradeniya

This project investigates the effect of lightning risks on heritage stupas in Sri Lanka. The selected Stupas were Jethawanaramaya, Abhayagiriya, and Ruwanweliseya in Anuradhapura kingdom, and Kirivehera, Rankothvehera in Polonnaruwa Kingdom. The standard protective angle method, rolling sphere method and its modified version have effectively been utilized to examine the risk of lightning on the selected stupas by considering their ancient and present structures and also with/without installed lightning protection systems. Lightning critical current values have been obtained for the unprotected parts of the stupas and their effects have been analyzed through simulations.

It has been found from the analysis that even if the mineral/spire of a stupa is protected by a lightning protection system, a direct lightning may strike on the square chamber or the dome of the stupa. The results also show that the reduction of heights of the spires of the stupas during their renovation could increase the lightning risk. In general, the lightning critical currents are higher in modified rolling sphere method compared to the standard rolling sphere method as the upward leader initiated from the top of the structure is taken into consideration in the modified version. It can be concluded that the estimated critical currents describe the effectiveness of the lightning risk based on their values and the cumulative probability of occurrences.

Design of a 24GHz Microwave Ring Resonator for Condition Assessment of Transformer Pressboard Insulation

H.M.L.G.K. Herath[1], K.K.K.S. Jayashantha[2], P.W.M.H. Polkotuwa[3]
Supervised by: Dr. J.R.S.S. Kumara[4], Prof. M.A.R.M. Fernando[5], Dr. A.U.A.W. Gunawardane[6]

[1]lihiniherath@gmail.com, [2]kanishkasandaruwan7@gmail.com, [3]madhawapolkotuwa@gmail.com, [4]jagathk@ee.pdn.ac.lk, [5]manjula@ee.pdn.ac.lk, [6]aruna@ee.pdn.ac.lk

[1-6]University of Peradeniya

The performance of power transformers plays a vital role in power system reliability. Hence the condition assessment of transformers are very essential. Increasing moisture content with aging of transformer is the main factor that causes failure of transformer insulation. This project presents a method for estimating the condition of transformer pressboard insulation (i.e. moisture content) based on measurements of the relative permittivity and the loss tangent. These measurements are done using a microwave ring resonator at high frequencies up to 24 GHz.

The ring resonator was designed for a fundamental of 6 GHz and measurements at 24 GHz were made observing the 4th harmonic. The ring was fabricated on a material of known dielectric properties and the pressboard samples were placed on the ring resonator. The loss tangent and relative permittivity were determined by the measuring S21 using a vector network analyzer. The results of preliminary study confirmed that the transitions from Coaxial connector to the microstrip is critical for high microwave frequencies like 24 GHz. To overcome associated matching issues the transition from CPW (Coplanar waveguide) to Coaxial waveguide was used with the CPW parameters optimized using HFSS. The performance of transition was verified using S11, S21 plots. These changes results in significant improvements.

Modeling of Lightning Induced Over Voltages in Power Transmission Lines

J.G.C. Jayalath[1], P.A.S.I. Perera[2]
Supervised by: Prof. Manjula Fernando[3], Prof. Disala Uduwawala[4], Dr. Sarath Kumara[5]

[1]gayanthichathurika12@gmail.com, [2]susanjee1994@gmail.com, [3]manjula@ee.pdn.ac.lk, [4]disala@ee.pdn.ac.lk, [5]sarath@ee.pdn.ac.lk

[1-5]University of Peradeniya

Lightning-induced over-voltages have become the most significant performance degrading factor for the power transmission network. The project is focusing on a highly lightning affected transmission line in Sri Lanka. It will be analyzing the available data to build models and methods to analyze the voltage and current distribution of the transmission line. The obtained results can be used to upgrade the existing safety measures of the transmission network.

A survey was carried out to gather data on lightning trip outs in 132kV and 220kV transmission network. Then survey result was compared with the Isokeraunic level map to select a highly lightning affected transmission line to model the effect. An analysis was done on power outages, monsoonal effects to determine whether the power outages are mainly caused by lightning. In addition to that, a risk analysis was done to identify the risk for the substation due to the lightning effects on the transmission line. Afterwards, Rolling sphere method was used to approximate the maximum current struck to a transmission line and then a model was developed to analyze the lightning induced voltage and current distribution over the transmission line using finite difference time domain method (FDTD). Finally, the simulation results were validated under high voltage laboratory conditions.

Classification of Generator Partial Discharges using Machine Learning Techniques

P.A.N.B. Pathirana[1], U.T.G.A.M. Wijesinghe[2], M.A.D.N. Wijewardena[3]
Supervised by: Dr. Sarath Kumara[4], Prof. Manjula Fernando[5], Dr. Janaka Wijekulasooriya[6], Dr. Chathurika Dharmagunawardhana[7]

[1]anjanapathirana375@gmail.com, [2]achintha.m.wijesinghe@gmail.com, [3]diliniwijewardena@gmail.com, [4]sarath@ee.pdn.ac.lk, [5]manjula@ee.pdn.ac.lk, [6]jan@ee.pdn.ac.lk, [7]chaththa85@gmail.com

[1-7]University of Peradeniya

Electrical insulation failure is one of the main causes of generator outages. However, such insulation failures are developed slowly and can be predicted by monitoring Partial Discharge (PD) activities. PD, which apperas before insulation failure, is an electrical discharge that occurs in part of an insulation system without completely bridging the electrodes. Even though PD monitoring is widely used in power plants for generator condition assessment, still there are no reliable methods to identify the PD sources. This project is focused on developing a method to identify PD sources by applying machine learning techniques to Phase Resolved Partial Discharge (PRPD) patterns.

In generator windings, PD can appear due to various sources, namely; end winding discharges, slot discharges, de-lamination, internal discharges, etc. The main activities of the project are: (a) identification the characteristics of few selected PD sources by means of laboratory experiments, (b) collecting PRPD patterns from major hydro power plants, and (c) applying machine learning techniques on the collected PRPD patterns and identifications PD sources. Up to now, studies are conducted for two types of PD sources found in two power stations. Results reveled that Neural network method is capable of seperating slot discharge and internal discharges successfully.

Hyperspectral Image Analysis for Feature Detection

E.M.M.B. Ekanayake[1], E.M.H.E.B. Ekanayake[2], A.R.M.A.N. Rathnayake[3], H.M.V.R. Herath[4], G.M.R.I. Godaliyadda[5], M.P.B. Ekanayake[6]

[1]mevanekanayake@gmail.com, [2]hasarajanse13@gmail.com, [3]anushanr94@gmail.com, [4]vrherath@googlemail.com, [5]roshangodaliyadda777@gmail.com, [6]mpb.ekanayake@gmail.com

[1-6]University of Peradeniya

A hyperspectral image is a collection of images depicting the reflectance values corresponding to a contiguous range of wavelengths. Importance of using hyperspectral images for feature detection is that they contain richer information due to the presence of multiple spectral bands. The objective of the project is to develop novel algorithms for various applications using hyperspectral images. Our focus has been directed toward solving remote sensing problems via hyperspectral images captured by satellites and other sensors.

Mineral detection using remote sensing techniques is important since it saves time and effort of carrying out manual land surveys. A novel algorithm was introduced to detect ilmenite, which yielded positive results for a test case in the region of Pulmudai, Sri Lanka. Continuous mapping of vegetation zones is vital to identify ecological changes as early as possible. A novel semi-supervised algorithm was introduced, to map major vegetation zones in a geological map. Due to the dismal spatial resolution of present hyperspectral images, a single pixel may comprise of a mixture of spectral characteristics. A novel method for hyperspectral unmixing was introduced, which yielded superior performance over the existing conventional methods. Apart from these outcomes, many feature extraction and machine learning concepts were studied.

Multispectral Imaging for Industrial Applications

W.G.C. Bandara[1], G.W.K. Prabhath[2], D.W.S.C.B. Dissanayake[3]
Supervised by: H.M.V.R. Herath[4], G.M.R.I. Godaliyadda[5], M.P.B. Ekanayake[6], S.M.D. Demini[7], T. Madhujith[8]

[1]chaminda.bandara@eng.pdn.ac.lk, [2]gwkprabhath@eng.pdn.ac.lk, [3]sahan.dissanayake@eng.pdn.ac.lk, [4]vijitha@eng.pdn.ac.lk, [5]roshanr@pdn.ac.lk, [6]mpb.ekanayake@ee.pdn.ac.lk, [7]deminismd@gmail.com, [8]madujith@yahoo.com

[1-8]University of Peradeniya

Multispectral imaging is a novel technology for obtaining both spatial and spectral information from an object. In recent years, multispectral imaging has rapidly emerged as a powerful and fastest-growing non-destructive tool for food quality analysis and control. Using the multispectral imaging, the spectrum associated with each pixel in a food can be used as a signature to characterize the biochemical composition of each pixel. As a result, multispectral imaging provides the potential for more accurate and detailed information extraction than is possible with other type of technology for the food industry.

As the first part of this research, a multispectral imaging system was developed based on the selected wavelengths from the Ultra-Violet (UV), visible and Near Infra-Red (NIR) regions of the electromagnetic spectrum with a resolution of nine spectral bands (405 nm, 430 nm, 505 nm, 590 nm, 660 nm, 740 nm, 850 nm and 890 nm). Next, a mathematical algorithm was developed to evaluate the quality of chicken meat stored at 4 ^{0}C using the Principal Component Analysis (PCA). In the latter part of the research, the developed multispectral imaging system was used to estimate the adulteration level of turmeric powder samples available in the market with the aid of PCA and multivariate statistical analysis methods.

Intruder Detection System Through Walking Pattern Analysis for Home Security

R.C.P.D. Peiris[1], R. Tharmikka[2], H.M.V.R. Herath[3], M.B. Dissanayake[4], U.S. Navarathne[5]

[1]charitha.dhananjaya@eng.pdn.ac.lk, [2]tharmikka10@gmail.com, [3]vijitha@eng.pdn.ac.lk, [4]maheshid@eng.pdn.ac.lk, [5]sudheera@eng.pdn.ac.lk

[1-5]University of Peradeniya

Modern home automation systems have home security enhancing features such as face detecting camera systems and fire alarm systems. In this project, a novel home security system is proposed which can detect intruders by analyzing walking patterns and updating the owner immediately. The system architecture adopts the concepts of Internet of Things (IoT), providing a network and user-friendly system, which supports simple expansion through plug and play devices.

The main concept of this project, intruder detection through walking pattern analysis is enabled by abstracting the surface vibration signals, which occurs when a person walks. Then time domain and frequency domain features are generated and employing Liner Discriminant Analysis (LDA) which is a supervised Machine Learning algorithm, those features are optimize for respective person. When a new signal is feed into the algorithm it calculates the probability of matching to each person the algorithm trained into. The threshold of 80% of probability is expected for a correct match if not the signal is detected as intruder.

Modelling the Performance of a Silicon Crystalline Solar Cell under Tropical Ambient Conditions

A.H.T.L.S. Hewage[1], S.N. Maheepadma[2], G.R.I. Disnaka[3]
Supervised by: Dr. Waranatha L. Abeygunasekara[4]

[1]lahirushanan@gmail.com, [2]samarasinghenm@gmail.com, 3ishandisnaka1@gmail.com, 4waranatha@ee.pdn.ac.lk

[1-4]University of Peradeniya

Photovoltaic cell (PV) is a device that converts the photon energy of sunlight directly into electrical energy. A fundamental physics based model for a Silicon PV was developed using commercially available Finite Element Method (FEM) based Multiphysics simulation software 'COMSOL'. Optical absorption and Charge extraction characteristics were mainly considered in the modelling process. The resulting device characteristics can be used as a prediction tool for PV performance at a given instance.

The performance modelling was done by using one dimensional and two dimensional geometries considering semiconductor physics and electromagnetic physics interfaces. As the first approach one dimensional geometry was used for the modelling and drift diffusion equations were used to model charge carrier extraction characteristics. Then it was extended for two dimensional model and basically Maxwell equations were used to model optical characteristics. The sun's position with the time of the day was also embedded into the model and then the corresponding I-V, P-V and generation curves were obtained. Those curves can be compared with the values in data sheets of commercially available solar cells to recognize the behavior of the cell at a particular instance.