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6th Electrical and Electronic Engineering Research and Project Symposium

EEERaPS 2023

ABSTRACT BOOK

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ELECTRICAL & ELECTRONIC ENGINEERING RESEARCH AND PROJECT SYMPOSIUM (EEERaPS) 2023

03rd November 2023

Abstract Book

Department of Electrical and Electronic Engineering

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University of Peradeniya

Message from the Head, Department of Electrical and Electronic Engineering

It is a great privilege to write this message as the Head of the Department of Electrical & Electronic Engineering, who has been producing the most versatile group of Electrical & Electronic Engineering graduates to the nation.

I earnestly expect you will enjoy exploring the undergraduate and the postgraduate projects presented at the Electrical & Electronic Engineering Research and Project Symposium (EEERaPS) 2023, where some of the work may be developed further as industry collaborations and/or advanced research, which will eventually benefit the mankind.

I strongly believe that this event will not only foster our students with a range of transferable skills but open up more opportunities to showcase their talents to the industry and pursue with successful future careers in Electrical & Electronic Engineering.

Prof. Lilantha Samaranayake
Head
Department of Electrical and Electronic Engineering

Message from the Undergraduate Project Coordinator

I am honored and excited to serve as the Undergraduate Project Coordinator for the Department of Electrical and Electronic Engineering (DEEE) at the University of Peradeniya. It is with great enthusiasm that I compose this message for the highly-anticipated Annual Research and Project Symposium, EEERaPS 2023.

At DEEE, we firmly believe in equipping our students to bridge theory and practice. We nurture critical thinking, analytical skills, and hands-on experience through extensive research projects in their final undergraduate years. These projects prepare students for advanced studies and industry demands, aligning with the globally recognized Washington Accord.

This year's symposium marks a significant milestone for us as we showcase the results of 34 diverse undergraduate projects, each delving into various facets of electrical and electronic engineering. These projects are a testament to our students' ingenuity, resourcefulness, and dedication. We encourage you to join us in this endeavor, as your insights, feedback, and collaboration can contribute to the enhancement and relevance of our projects, ultimately strengthening the bond between academia and industry.

I would like to express my sincere gratitude to all the dedicated staff members of the DEEE as well as our collaborators from around the world, whose unwavering commitment and support have paved the way for our students to undertake these valuable projects. It is through this collective effort that we continue to make a lasting impact on the field of Electrical and Electronic Engineering and society as a whole.

We look forward to your presence at EEERaPS 2023 as we celebrate the synergy between education, research, and industry. Together, we can shape a brighter and more innovative future.

Dr. Ruwan Ranaweera
Undergraduate Project Coordinator
Department of Electrical and Electronic Engineering

Message from the Postgraduate Coordinator

It is a true honor to write this message for the 6th Annual Research and Project Symposium of the Department of Electrical and Electronic Engineering at the University of Peradeniya. This event is an incredible opportunity for both undergraduate and postgraduate students to showcase their research findings and innovations, particularly to the local industry. The symposium will feature the results of numerous postgraduate projects in the fields of Electrical and Power Applications, Communication and Information Engineering, Control, and Instrumentation, as well as AI and Signal Processing. These investigations provide solutions for a competitive future world, and I'm confident that their outcomes will inspire new heights of technological innovation.

I would like to take this opportunity to express my gratitude to all the staff members who have played a crucial role in the postgraduate program of the Department. I am particularly thankful to those who have supervised the research projects and to the students who have demonstrated such outstanding research outcomes. It is my sincere hope that all the postgraduate students will utilize these outcomes to help develop their communities, as well as the world at large.

Dr. W. A. N. I. Harischandra
Postgraduate Coordinator
Postgraduate Program of the Department of Electrical and Electronic Engineering

Message from the Double Degree Program Coordinator

It is a great privilege to compose this message in honor of the 6th Annual Research and Project Symposium organized by the Department of Electrical and Electronic Engineering at the University of Peradeniya. This event provides a remarkable platform for both undergraduate (UG) and postgraduate (PG) students to present their research discoveries and groundbreaking innovations to the industry. The symposium will showcase a multitude of projects spanning the wide domain of electrical engineering. I am confident that these results will serve as a source of inspiration for driving technological advancements to new heights.

I would like to seize this moment to extend my heartfelt appreciation to all the dedicated staff members of both the University of Oulu and the University of Peradeniya who have played a pivotal role in the dual degree program. I am particularly grateful to those who have guided and supervised the research projects and to the students who have demonstrated exceptional research outcomes. It is my sincere wish that all students will harness these accomplishments to contribute to the betterment of their communities and the world at large.

Dr. Isuru Dasanayake
Coordinator of the Double Masters Degree Program Between University of Oulu, Finland and University of Peradeniya
Department of Electrical and Electronic Engineering

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UNDERGRADUATE PROJECTS

Intelligent Signal and Modulation Classification for Wireless System Implementation

J.K.D.D.T. Jayawardena[1], J.P.D.D.M. Jayawickrama[2] and K.D.K.I. Nanayakkara[3]
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Modulation classification is a pivotal aspect of modern communication systems, aimed at the identification of the modulation scheme applied to received signals. Conventional approaches often rely on IQ samples and machine-learning techniques, which may fall short in adapting to the intricate characteristics of real-world signals. Through this project, we introduce a generalized approach to modulation classification that harnesses the power of deep learning in conjunction with higher-order cyclic cumulants.

Higher-order cyclic cumulants capture cyclostationary features of modulated signals, providing a more comprehensive description of the modulation properties. The performance of this approach is evaluated on five different modulation schemes and signal-to-noise ratios (SNRs). Our study proposes a deep learning framework that utilizes higher-order cumulants as input features for modulation classification. The results showcase that our deep learning-based modulation classification using higher-order cumulants surpasses traditional methods, achieving exceptional classification accuracy of 99% and resilience in noisy environments. Notably, the model exhibits robust generalized capabilities, making it applicable to unobserved modulation schemes in varying SNR conditions and varying carrier frequency offsets.

The proposed approach represents a promising solution for accurate and adaptable modulation classification in the context of contemporary communication systems, ultimately enhancing the reliability and performance in the presence of diverse signal types and environmental conditions

Keywords: Modulation classification, higher-order cyclic cumulants, deep learning, cyclostationary features, wireless channel.

Machine Learning based Intelligent Human Motion Trajectory Estimation and Re-Identification

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In this project, we propose an innovative approach to human re-identification, a challenging task involving the matching of individuals across non overlapping camera views. While previous studies predominantly rely on single biometric features, we use a multi-modal strategy encompassing face, gait, and clothing attributes to significantly enhance accuracy, especially in the context of long-term re-identification. Our exploration begins with pose-based attributes, where we introduce novel metrics based on body ratios and the eigenvalues derived from their autocorrelation matrix. This approach has proven to be highly effective, achieving an accuracy of eight out of 10 for person re-identification. Additionally, our study delves into gait-based features, including velocity, angles, and distinctive patterns of movement. An intermediate step involves estimating the trajectory of individual, providing crucial walking direction inputs for the model. To enhance the quality of the trajectory, we employ both the Savitzky-Golay filter and polynomial fitting, ensuring smoother paths. We extract facial, gait, and clothing features using established models, and combine to form a single feature vector which then undergoes training through Siamese networks, incorporating a Convolutional Neural Network (CNN) architecture. This comprehensive fusion leads to an enhancement in re-identification accuracy.

Our research leverages on the CCVID dataset, known for cloth-changing scenarios, even in low-resolution settings. Notably, this approach overcomes challenges posed by the dataset, holding substantial promise for real-world re identification scenarios.

Keywords: Human Re-Identification, autocorrelation matrix, convolutional neural networks, Savitzky-Golay filter, polynomial fitting, gait-based features, feature vectors.

Identification of Attention Level by Gaze Recognition Using a Semantic Communication System

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Artificial Intelligence plays a significant role inside classrooms with the rapid development in online education with the Covid 19 pandemic. However, the bandwidth limitations, lack of visual feedback and difficulty in keeping attention in a virtual environment remains a gap between in-person learning environment and virtual learning environment. This work proposes a solution in bridging this gap through image processing, machine learning and the principles of communication.

The proposed model estimates the gaze utilized towards the detection of one's attention focusing on visual attention and real time transferring the data over a semantic communication channel. Gaze estimation has the potential to predict the point on screen where the user is looking. That is then mapped into a level of attention through a predefined attention metric based on areas of the screen depending on the presenting material. The semantic communication is capable of providing key points of one's video feed into the processing end such that a high-quality video feed can be reconstructed at the processing end supporting both machine vision and human perception jointly. This drastically reduces the usage of bandwidth sounding good for a bandwidth limited environment. Additionally, we have created a comprehensive dataset encompassing various environmental conditions and subjects, enhancing the robustness of our approach. The proposed method is capable of predicting the attention through mapping of facial landmarks obtained with a single webcam which can easily replace the available wearable devices at the market.

Beyond the implications for online education, our project extends its utility to identifying attention-related conditions in children, and addressing concerns like driver fatigue. Furthermore, the versatility of this approach finds applications in diverse fields, including healthcare, transportation, and security.

Keywords: Artificial intelligence, gaze estimation, image processing, machine learning, visual attention, semantic communication, machine vision, bandwidth limited communication, facial landmarks.

Spiking Neural Network Architecture for Information Processing

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The field of Artificial Intelligence (AI) has attracted significant attention due to recent advancements and breakthroughs. While these developments have enabled AI systems to mimic human decision-making to a great extent, the processing elements that run AI algorithms still require much more power compared to the human brain. Many AI applications require a large number of nodes to achieve a certain level of accuracy. As the number of nodes grows, the power demand will increase exponentially. This suggests that the Von Neumann architecture, which underpins modern computers, may not be the correct choice when performing AI-related calculations. Hence, in light of this growing need, researchers are increasingly focused on creating technologies that can harness the efficiency of the human brain. Spiking Neuron Networks (SNN) is one such promising approach, that aims to replicate the decision-making and information processing of biological neuron networks. In this study, we successfully replicated the decision-making accuracy of Artificial Neural Networks (ANN) inference by implementing an equivalent SNN by using Izhikevich neurons. These neurons were implemented on the Field Programmable Gate Array (FPGA) platform, and detailed comparisons were made between the inferences from the ANN and the SNN. We demonstrated that the event-driven nature of spiking neurons significantly reduced the number of calculations required while still achieving comparable results.

Keywords: Spiking neural networks, artificial neural networks, Izhikevich neurons, FPGA, efficiency comparison, power consumption, image classification, MNIST dataset.

Fault Tracking Framework for RISC-V Architecture

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The RISC-V architecture has emerged as a promising open instruction set architecture, gaining widespread popularity due to its simplicity, flexibility, and support for various platforms. In recent years, there has been a substantial increase in software development and support for RISC-V, which has further solidified its position as a reliable choice for hardware development. Fault models are simplified representations of potential defects or errors that can occur in digital circuits. These models help in analyzing, testing, and diagnosing faults in circuits, ensuring their proper functioning. Common fault models include the stuck-at fault model, which assumes lines can be stuck-at-zero or stuck-at-one due to permanent defects. Design for Testability (DFT) is crucial in integrated circuit (IC) design, aiming to simplify testing during manufacturing and validation. DFT integrates features and techniques for fault detection and diagnosis, enhancing IC testability and reliability. Engineers employ specialized closed-source software for software-based fault injection and tracking in integrated circuit design for closed-source computer architectures. The project involves developing a fault injection and tracking framework for the RISC-V based processor. RISC-V is an open computer architecture that is becoming increasingly popular in academia as well as industry. Our software enables controlled fault introduction and behavior analysis at circuit level or at system level. Detecting faults helps to enhance IC production quality and characterized the behavior for specific applications. In this process, the Verilog files, initially in behavioral design, are transformed into gate-level design. To test sequential circuits, the manual addition of scan chains is required. Flip-flops are removed from the circuits and those serve as inputs points for the PODEM (path-oriented decision-making) and ATPG (automatic test pattern generation) algorithm, which generates input test vectors for potential fault nodes within the circuit. Faults are injected into the input Verilog files, and both faulty and fault-free outputs are recorded. The test vectors generated by the PODEM algorithm serve as inputs to assess the faulty outputs. By comparing these outputs with their fault-free counterparts, the presence of faults can be verified.

Keywords: RISC-V, fault models, stuck-at-faults, DFT, PODEM, ATPG, test vectors, Verilog Gate level design, sequential circuits, combinational circuits, scan chain, IC, fault injection, fault detection

Designing Hardware Accelerators for RISC-V for ML Applications

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In this cutting-edge project, we embark on the development of a custom chip for character recognition, utilizing the open-source RISC-V instruction set architecture. The endeavor is divided into two distinct stages, aiming to manifest a manufacturable product with a strong emphasis on machine learning and hardware acceleration.

In the initial phase, we deploy a machine learning algorithm of our choice to classify characters from the MNIST database. We further delve into the intricacies of the RISC-V processor, enhancing its capabilities with dedicated hardware accelerators designed to expedite machine learning calculations. A primary focus here lies on stochastic computing, offering promising advantages for efficient computation.

With the development of a hardware accelerator, we center our efforts on optimizing the stochastic gradient descent algorithm. Rigorous performance analysis is conducted throughout the project, considering factors such as energy efficiency and training time. Our findings substantiate the practicality and benefits of hardware acceleration within the RISC-V architecture for machine learning applications.

This project embodies innovation and exemplifies the potential of custom chip design, harnessing the power of RISC-V and stochastic computing to propel the boundaries of machine learning, particularly in the realm of character recognition.

Keywords: RISC-V, character recognition, custom chip, machine learning, stochastic computing, FPGA, hardware acceleration, energy efficiency, training time, AI applications.

Advanced Driver Assistance Systems: Vision based Lane Departure Detection for adverse weather conditions

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This research presents an innovative approach to enhance road safety through the development of an Advanced Driver Assistance System (ADAS) using image processing and deep learning architecture. The core of the proposed system is a Fully Convolutional Neural Network (FCNN) that efficiently detects drivable areas and predicts lane departures in real-time using data from a dashboard camera. The system's primary objective is to prevent accidents caused by lane departure, a significant contributor to road accidents. The system's easy deployment is an important feature that aims to give ADAS functionality to vehicles without built-in systems provided by the manufacturer. The FCNN was trained to achieve robustness and generalisation, ensuring reliable performance across various scenarios. This was accomplished by utilising a diverse and wide-ranging dataset including various road conditions. The presented work's innovation lies in the combination of deep learning for improving undetected lane-lines, lane segmentation and detection, along with a novel image analysis algorithm for departure prediction. The system provides drivers with immediate alerts about deviations from the intended path. These alerts are made to minimise interruptions while effectively delivering important information. Despite the great potential of the concept, there are a few limitations that need to be carefully considered. The system was developed with the assumption that the mounted dashboard camera is aligned with the vehicle. Also, at deployment it is essential that the system is able to perform under low computational power in a fast and accurate manner. Ongoing work of this research is focused on investigating potential low computational power models with fast and higher accuracy, and visibility improvement in adverse weather conditions. In summary, the proposed model showcases the capabilities of deep learning in positively impacting road safety, and demonstrates its impact in modernising driving experiences.

Keywords: Deep learning, visual-based, lane departure, prediction, ADAS, FCNN.

Electrophysiologic biometric markers for Early Diagnosis of Neurodegenerative Diseases

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The work presented in this project proposes a novel technique for early diagnosis of neurodegenerative diseases such as Alzheimer's Disease, Parkinson's Disease, and Dementia by utilizing information in electroencephalography (EEG). Despite advancements in technology, diagnosis of neurodegenerative diseases is still an expensive and challenging process. The proposed technique exploits the ability of using EEG data to derive functional connectivity of the brain to predict diseases using changes in connectivity maps using Artificial Intelligence. The proposed technique combines EEG data processing, head model generation, scout time series extraction, and connectivity analysis to generate functional connectivity metrics such as the coherence matrix. This connectivity data is then used to train a machine-learning algorithm to identify neurodegenerative diseases.

Our approach starts with eyes-closed, resting-state EEG data acquisition. The raw EEG data is then preprocessed to remove artifacts and enhance data quality. A comprehensive head model is then generated using an anatomical MRI of the head to map electrophysiologic activity accurately to their sources. The coherence matrix is then generated which serves as a crucial representation of functional connectivity between different brain regions, aiding in the identification of potential disease biomarkers. This matrix forms the input to our machine learning algorithm, which is trained to recognize patterns and subtle changes in functional connectivity indicative of early disease stages.

Our approach has the potential to revolutionize early disease diagnosis, offering timely intervention and improved patient outcomes. The system promises to make significant contributions to healthcare by enhancing early, low-cost disease detection and providing valuable insights for proactive medical intervention to slow down the disease.

Keywords: Neurodegenerative diseases, electroencephalography, biometric marker, functional connectivity, coherence matrix.

Vision-Based Road Traffic Violation Detection

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In recent times, the surge in on-road vehicles has posed significant challenges, particularly in developing nations such as Sri Lanka, where existing infrastructure struggles to cope with the increasing vehicular population. Among the myriad issues encountered, a pressing concern is the rise in traffic violations at pedestrian crossings. To address this problem, we propose an innovative and comprehensive approach harnessing cutting-edge technologies, including YOLOv5 and DeepSORT. The methodology comprises several stages, from video footage recording and object detection with YOLOV5 and DeepSORT to creating labeled datasets. Accuracies of 86.27%, 85.01%, and 87.53% were achieved using machine learning models: Support Vector Machines (SVM) , Linear Regression, and Random Forest classifiers, respectively.

This approach efficiently and accurately detects pedestrian crossing violations by employing machine learning models and a 2D feature extraction matrix rather than processing entire video frames. Additionally, a novel algorithm was developed that incorporates position and motion vectors, resulting in an impressive 84.16% accuracy rate. All these methods successfully detected violations at pedestrian crossings, enabling violation frame capture and saving for further analysis. Future directives include improving model accuracy by implementing LSTM and GRU models, considering temporal data, and expanding model capabilities to detect overtaking at pedestrian crossings. These advancements are expected to significantly contribute to the reduction of pedestrian crossing violations and enhance overall traffic safety.

Keywords: Traffic violation, pedestrian crossing, road traffic, computer vision, machine learning, YOLO, DeepSORT, SVM, LSTM, GRU.

Deep Learning Based Traffic Sign detection and Recognition for Safe Driving

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Traffic signs play a critical role in managing road traffic, enforcing discipline among drivers, and ultimately preventing accidents, injuries, and fatalities. With the emergence of Artificial Intelligence (AI), vehicle-aided driving systems have been developed to acquire real-time road condition information, enabling timely reminders to drivers for accurate actions and effectively preventing car accidents due to driver fatigue. This project introduces a deep learning-based model for the Traffic Sign Detection and Recognition (TSDR) system, integrated as an essential component of Driving Assistance Systems. In the detection phase, the model is deployed to identify potential traffic signs from live video streams captured by onboard cameras. Following successful detection, the recognized traffic sign candidates undergo a sophisticated recognition process This project employs a combination of image preprocessing, feature extraction, and classification methods, as well as the YOLO (You Only look Once) algorithm, to accurately classify and localize detected signs within video frames, with an accuracy of up to 92% depending on the lighting and whether condition. By expanding the training dataset of the model to encompass a wide range of sign variations, the system ensures high accuracy even in challenging occlusion scenarios. This extended capability represents a promising solution to enhance road safety by providing drivers with real-time alerts regarding relevant traffic signs. Consequently, the system effectively reduces the likelihood of accidents and promotes adherence to traffic regulations, ultimately contributing to the development of safer and more efficient transportation systems, thereby saving lives and improving the overall travel experience for all road users.

Keywords: Traffic sign detection and recognition**,** driving assistance systems, feature extraction, YOLO, real-time alerts, safer transportation systems.

Road Traffic Rule Violation Detection in Adverse Weather Conditions

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Every day, road traffic accidents claim a staggering toll of 3700 lives, with a distressing 65% attributed to violations of traffic regulations. To mitigate this dire consequence, effective inspection assumes paramount importance. However, the challenge lies in maintaining continuous 24x7 surveillance, especially under adverse weather conditions. In response, we propose an innovative system capable of autonomously detecting traffic rule violations even in unfavorable weather scenarios. Our solution is rooted in the fusion of computer vision and deep learning. The framework encompasses three key stages. Initially, a multiclass classification model adeptly distinguishes prevailing weather conditions, encompassing rain, fog, and darkness. Subsequently, weather-specific enhancement algorithms are meticulously employed to enhance image visibility. The culmination involves a sophisticated neural network that accurately identifies instances of traffic rule transgressions. The project unfolds in two pivotal parts. The first involves precise weather condition estimation and the application of suitable quality enhancement algorithms. The primary aim of this phase is to significantly enhance image visibility, thereby facilitating the extraction of critical features for subsequent traffic violation detection. Our investigation yields compelling findings. Employing wavelet transform alongside the dark channel method effectively eliminates haze, while contrast improvement and gamma correction techniques adeptly counter rain-induced distortions. Moreover, darkness is deftly mitigated through a simple yet powerful statistical transformation, fortified by reference images. Integral to our approach is the robust training of a multiclass classification model, achieved via transfer learning with GoogleNet and the DAWN dataset. Our trained model exhibits an average F1 score of 94.35%. Image quality is evaluated through a subjective assessment. In conclusion, our study underscores the effectiveness of distinct algorithms combined with a multiclass classification model in enhancing image visibility amidst adverse weather conditions.

Keywords: Traffic accidents, adverse weather, multiclass classification, image enhancement, deep learning, traffic rule violations.

Semantic Instance Segmentation in a Dynamic Environment

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Computer vision has been a hot topic among researchers for the past few decades. Interest in the technology grows as it can be used in multiple domains and has endless applications. Autonomous vehicles can be built by incorporating computer vision for various applications. Information about the vehicles around can be gathered using computer vision techniques. This information can be processed in order to make useful decisions.

Our work focuses on the application of speeding in a vehicle. This work proposes a system that provides a 'Risk Factor' while speeding an object, a vehicle, in the sense of a road scenario. The system utilizes YOLOv7, a SORT tracker, and an algorithm to compute the risk factor depending on the bounding box area. The SORT tracker consists of a Kalman filter, which outputs a state vector in which the elements are the measurements of the bounding box and the rate of change of the measurements.

The area of the bounding boxes and the rate of change of the area of the bounding boxes are the elements included in the state vector output by the Kalman filter. We are extracting the rate of change of the area of the bounding boxes out of the state vector, and an algorithm has been developed to generate a 'Risk Factor' depending on the stream of values of the rate of change of the area of the bounding boxes. For instance, if the value of the rate of change of the area of the bounding box is large for a stream of frames, it is decided that the vehicle corresponding to that bounding box is nearing us, and it is notified with a 'High Risk Factor'. The proposed system is useful for giving the controller of the vehicle an idea of speed while driving.

Keywords: Segmentation, computer vision, risk factor, Kalman filter, YOLO.

Design of an Interferometric Biomedical Radar for Contactless Detection of Breathing and Heartbeat

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In modern healthcare, contactless detection of vital parameters of human beings has become an important factor. Among those vital parameters, the detection of heart rate and breathing are of great importance.

Our project developed a biomedical radar specially designed for the contactless monitoring of breathing and heartbeat. The radar is based on interferometry at microwave frequencies. The proposed interferometric radar system was designed using an electronic design and automation tool, namely the Virtual System Simulator (VSS) of AWR Microwave Office software by Cadence Inc. The radar transmits a low power signal of 10 dBm at 5.8 GHz, towards a subject who is 40cm away from the transmitter. The reflected signal comprises the delayed reflections from the chest cavity due to heart and lung motions. By analyzing the phase shift in these reflected signals, the system extracts the heart rate and breathing information. Here, phase extraction is done using arc tangent demodulation. The proposed system was built using off-the-shelf microwave components and several of our own designs such as microwave bandpass filters, couplers, etc. The performance of the system was tested using a microwave Vector Network Analyzer (VNA) and a spectrum analyzer.

Key advantages of this system include its ability to operate at a distance from the subject, eliminating the need for physical contact or electrode attachments. Moreover, this approach is particularly beneficial when monitoring patients in situations where hygiene and comfort are of great importance. This also has the potential to revolutionize elder care as the proposed radar can monitor heart rhythm and breathing contactless during sleep and alert caregivers when attention is necessary. It has the potential and ability to modernize patient monitoring, improve diagnostic capabilities, and ultimately save lives.

Keywords: Interferometry, biomedical radar, microwave technology, vital parameter measurement, arc tangent demodulation, health care applications.

FMCW and Continuous Wave Hybrid Radar for High-Rise Building Wind Deflection Monitoring

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Monitoring the structural health of high-rise buildings requires careful attention to the deflections caused by wind loading effects. When wind-induced deflection is significant, it may damage the structural integrity of a building.

This innovative radar system, designed with cost-effectiveness in mind, addresses the formidable challenge of measuring and tracking building deflection caused by wind loading. Leveraging AWR Microwave Office (AWRMO) software for system modeling, HFSS software for antenna design, and MATLAB for radar cross-section modeling, the project aims to design a radar for accurate measures of deflection. The project can be divided into several steps, such as design parameter selection, radar modeling, antenna design, layout and board design, and algorithm development. The system comprises a stable transmitter and receiver, positioned at a fixed distance from the high-rise building to capture reflected signals. The radar system employs interferometry techniques, providing precise measurements of deflection. A probe-fed antenna was chosen for the radar system. The performance of this antenna was evaluated in terms of bandwidth, radiation pattern, and impedance matching.

With the potential to revolutionize structural monitoring, this radar system promises to offer critical insights into building safety and performance. Through rigorous testing and validation, this innovative system aims to make a significant contribution to the field of structural engineering and building safety.

Keywords: High-rise buildings, wind-induced deflection, radar system, Interferometry, AWR Microwave Office, HFSS software, probe-fed antenna, real-time monitoring.

Beamforming and Beam Tracking in Reconfigurable Intelligent Surface Assisted Wireless Communication System

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Wireless networks have transformed global communication with their high data speeds and energy efficiency yet face challenges like limited coverage and high-power consumption. Recently, Reconfigurable Intelligent Surface (RIS) technology has gained significant research attention as a solution to these issues. RIS, a two-dimensional structure comprising passive elements with PIN diodes, enables precise control of incident wave phases for intelligent signal routing.

Most recent RIS research has primarily focused on 1-bit RIS. To advance the existing body of work, we introduced a novel 2-bit RIS. The number of bits determines the phase shifts RIS can introduce, which impacts efficiency. This RIS was designed for 4 phase shifts, and simulation results showed that having more RIS elements improves array beamforming. With more elements, the beam narrows where needed and expands beamforming options, leading to higher gain with a larger array, successfully verifying the novel design. A beam-tracking technique was developed within a vision-based localization framework to efficiently adapt RIS beams to user mobility conditions and adjust their direction. This approach includes user identification, positioning, and tracking and they refer to managing and optimizing the data transmission in the wireless network, and results have yielded potential solutions. RIS integrated with the localization system developed guarantees proper coverage with better SNRs uniformly across cell regions ensuring a strong and reliable signal for the users.

Keywords: Reconfigurable Intelligent Surface (RIS), wireless communications, 5G, phase control, user mobility, computer vision, beam tracking, beamforming.

Optimum cycle clusters to create net-zero transport sector within the University of Peradeniya

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Many green environments are affected by the use of motorized vehicles. Considering the University premises as a case study this research proposed an electric bicycle sharing system so as to reduce the carbon emission from the vehicles and to facilitate pedestrian commuting. In achieving this, the locations of the e-bicycle parking stations, and the number of bicycles needed at each parking station needed to be obtained while optimizing the available resources and minimizing the waiting of the users. The methodology for this research involves collecting data using Google Maps, and two GPS trajectory tracking applications. Multiple clustering algorithms were used to analyze GPS data to identify optimal parking stations for the bicycle sharing system. The data was used to develop a computer simulation model which simulates the e-bicycle sharing system. The model was designed to simulate various scenarios to minimize waiting for users and maximize bicycle utilization. This research also proposes solar PV charging at each parking station. The optimum size of the components is selected such that the net cost is minimized. The collected data, simulation results, and probability curves were analyzed using descriptive statistics and data visualization techniques. The research offered recommendations for the optimal number of parking stations and bicycles to be deployed in each parking station, considering the potential scalability of the system. In conclusion, this project showcases the successful integration of data collection and analysis to optimize the e-bicycle sharing system. Through data-driven insights and heuristic guidance, the system achieves an efficient number of bicycle parking stations and bicycle allocation for each parking station, enhancing sustainability and user satisfaction.

Keywords: Bicycle sharing system, GPS trajectory analysis, cluster analysis, simulation model, PV charging station.

Agro-voltaic Simulation and Precision Agriculture Prototype

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According to their sustainable development objectives, the United Nations prioritizes food security and sustainable energy goals as key areas of their agenda. This research proposes a multifaceted approach to address those SDGs, food security, and sustainable energy sources. The core of the solution is an agro-voltaic system that integrates solar panels with agriculture to extend the traditional two-season agricultural cycle to three seasons, even in arid regions with limited water resources. The research also incorporates sensor networks and a Supervisory Control and Data Acquisition (SCADA) system to enhance the efficiency, and effectiveness of the agro-voltaic solution. The sensor network provides real-time data on soil temperature, atmospheric temperature, humidity, and soil moisture content. The SCADA system leverages this data to make informed decisions regarding water supply and energy distribution, ensuring the optimal allocation of resources and elevated agricultural productivity and energy efficiency. Economic analysis has revealed that the utilization of two-strip and three-strip PV panels, as opposed to conventional modules, yields the optimal outcome in terms of both agricultural productivity and energy generation. This comprehensive solution holds the promise of increased income opportunities for farmers and contributes to the supply of clean energy to the grid, thereby propelling the cause of sustainable development forward.

Keywords: Agro-voltaic, Optimum level, energy and water scarcity, dual benefits, solar farming, economic analysis, sensor network.

Design, Modelling, and Control of a 5kW Bidirectional Charger for Solar power-based Energy Mobilization Eco-System

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The earlier stages of EVs came with unidirectional charging that has the grid-to-vehicle power flow capability. With the rise of EVs in the global market and the steadily growing EV population, the idea of integrating of EVs into the power grid as energy storage has been discussed in the current literature on power electronics. To realize an EV as a power storage, Grid to Vehicle (G2V) and Vehicle to Grid (V2G) power flow capability should be established in the EV. The concept of a charger that has the bidirectional power flow capability has been proposed and topologies of such chargers are discussed in the literature. In this research, a two-stage 5kW bidirectional charger is designed using a totem pole power factor correction (PFC) boost converter topology. It acts as a PFC boost converter in G2V mode and as an inverter in V2G mode. A dual active bridge dc-dc converter is used as the secondary stage dc-dc converter in both V2G and G2V modes. The closed-loop control scheme is designed for the proposed bidirectional charger, and it is simulated with full features. In the G2V mode, the power factor (PF) is corrected from 0.69 to 0.99 at the grid input in the simulation. The dc bus is regulated to 400V with 5083.25W power flow. The Total Harmonic Distortion (THD) of the input current is 5.392 and the voltage ripple at the dc bus is 4.13%. The Dual active bridge dc-dc converter regulates the charger output voltage at 60V. In the V2G mode the output grid voltage of 230Vrms is achieved with 0.99 PF and a 4.0 THD of the output voltage.

Keywords: Bidirectional charger, Totem Pole PFC, dual active bridge.

Infrared Image-Based Condition Assessment of Lightning Surge Arresters

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Lightning surge arresters are key components for the protection and reliability of power systems. During service, surge arresters are aged by deteriorating their properties. It is important to monitor conditions periodically in order to avoid failures and damages in the power apparatus. A surge arrester consisting of arrester material (ZnO) housed by insulation (silicone rubber/porcelain) is usually exposed to electro-environmental stresses. Therefore, the condition of the internal arrester material cannot be assessed directly. However, with aging, the leakage current inside the arrester increases resulting in an increase in temperature. This study proposes an online-based condition monitoring method for 33 kV surge arresters which are used in the distribution network of Sri Lanka. Thirty samples of 33 kV silicon rubber insulated ZnO surge arresters with service years from 0-20 years were selected for the study from Peradeniya area which has a high keraunic level of lightning in Sri Lanka.

As the first stage, statistical analysis and thermal image processing of infrared images captured from energized lightning surge arresters were done and results were validated by FEM-based modeling. Recommended Thermal imager was used for capturing. Temperature profiles and statistical information (central tendency, box plot, violin plot) of the arresters were obtained by thermal image processing methods. The results of the above observations were compared with the built model from COMSOL Multiphysics software. The COMSOL model is validated to obtain any defects within the surge arrester. As a result, the physical properties of the surge arrester that will affect the temperature variations were identified under different conditions. As the second stage, a laboratory investigation was done on field aged arresters. A leakage current measuring setup was designed to measure leakage current. With insulation resistance leakage current measurements and the temperature data from the thermal images, the relationship between leakage current and temperature profile of lighting surge arresters will be obtained using Principal Component analysis and classification techniques.

Keywords: 33 kV lightning surge arresters, thermal imaging, FEM, COMSOL, leakage current measurement, PCA.

Hand Gesture Recognition and Gait Analysis via Wearable Devices

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The widespread integration of wearable devices in various fields has paved the way for numerous novel applications in medicine, rehabilitation, sports, etc. through the data acquisition, and analysis of hand gestures and gait patterns using wearable devices. This study aims to explore machine learning and pattern recognition techniques to gain insights into human movement patterns, together with gait parameter extraction under various environmental and other varying parameters. Additionally, the research endeavors to develop a wireless device to improve the existing wired device, presenting promising implications for clinical settings, sports, rehabilitation, and other relevant applications.

First, familiarization with the methodologies employed in the existing wired device was considered to achieve these objectives. Subsequently, data collection of hand gestures and walking patterns was conducted using the wired wearable device, and an in-depth analysis of the collected data was performed. Ground truth validation was also pursued to ensure the accuracy and reliability of the acquired data. After the pros and cons of the current wearable device were identified, a wireless alternative has been developed that addresses potential limitations and offers improved functionality and efficiency.

In conclusion, this research underscores the potential of wearable devices in hand gesture classification and gait analysis. By employing machine learning and pattern recognition techniques, significant insights are gained into human locomotion patterns, offering valuable applications in clinical settings, sports, rehabilitation, and beyond. The development of a wireless device is an innovative improvement over existing technology, solidifying the research's contributions to wearable technology and human movement analysis.

Keywords: Wearable devices, machine learning, pattern recognition, gait analysis, wireless device, wired device, sports, rehabilitation.

Deep Learning-Based Hyper-Spectral Unmixing for Lithological Mapping

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Hyperspectral imaging has revolutionized remote sensing, enabling detailed surface material analysis with high spectral resolution. This project focuses on lithological mapping of Montmorillonite, a versatile clay mineral, using data from NASA's Earth Observing-1 (EO-1) satellite's Hyperion sensor.

Traditional manual lithological mapping through resource-intensive field surveys is time-consuming. Digital lithological mapping, using remote spectral imaging techniques, provides an efficient alternative. It relies on generic end-member mineral signatures for spectral analysis, but site-specific impurities can affect accuracy. This study presents an approach using a hybrid deep learning and signal-processing algorithm to address this issue. Additionally, a soil pixel alignment strategy is introduced to assess relative mineral purity. These methods are validated through case studies mapping Montmorillonite deposits around Giant Lake in Mannar, Sri Lanka. Satellite-based spectral imaging findings are confirmed by X-ray diffraction (XRD) and Magnetic Separation (MS) analyses of soil samples collected during field surveys. A strong consistency is observed between spectral imaging and XRD/MS results, underlining the methodology's robustness.

This research highlights the potential of advanced remote sensing techniques and innovative strategies in enhancing digital lithological mapping accuracy.

Keywords: Hyperspectral imaging, lithological mapping, Montmorillonite, remote sensing, digital mapping, deep learning, signal processing, hyperspectral unmixing.

Multi-Person Action Spotting and Video Interpretation via Deep Learning

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In the realm of sports analysis, where continuous video streams are recorded, locating specific actions efficiently remains a significant challenge. Traditional methods are time-consuming, require greater levels of human assistance, and lack precision, prompting the need for advanced solutions. Since action recognition lags behind object detection due to its temporal complexity and need for contextual understanding while promising, current sophisticated techniques require refinement for practical use. In this project, we present a pioneering approach to multi-person action spotting and video interpretation through deep learning techniques.

Video action recognition goes beyond object detection by not only identifying objects but also understanding the actions associated with those objects over a sequence of frames. With that being mentioned, we have implemented and fine-tuned state-of-the-art Convolution based and Transformer based Neural Network architectures for video action recognition. Notably, our innovation lies in the fusion of these architectures to enhance video scene interpretation capabilities significantly. The fusion process enables a more nuanced understanding of complex actions within recorded videos. Our comparative study focused on evaluating the architectures' performance using metrics such as accuracy, inference analysis, and class analysis on simple to complex standard datasets. Particularly, our attention was drawn to the novel architectures, such as VideoMAE and mae_st which are utilized with the "self-attention" mechanism, alongside the well-established C3D and SlowFast Networks. Despite the promise these architectures hold, challenges such as time-intensive training procedures, the need for high computational power, and debugging complexities were navigated.

The fusion of architectures presented in this research has been evaluated with standard datasets and observed improvement in accuracy. That offers a pioneering leap in the field of multi-person action spotting and video interpretation.

Keywords: Video scene analysis, action recognition, deep learning, convolutional neural networks, Transformers, sport analysis.

Dynamic System Response Analysis and Improvement of PMSM Position Sensor Offset Compensation

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Permanent Magnet Synchronous Machines (PMSM) are prevalent in transportation electrification, renowned for their torque density and control simplicity. For optimal torque production in these machines, field-oriented control (FOC) demands precise rotor position measurement, typically achieved using encoders, resolvers, or linear hall sensors.

However, the harsh conditions in transportation systems can lead to misalignments of these position sensors from their calibrated positions. Previous research highlights the criticality of position signals in a PMSM drive system, demonstrating the system behavior during a position sensor offset error (PSOE). Previous research introduced an innovative algorithm to quantify the induced error in real time using voltage estimation, supported by both simulation and experimental data, and here we have extended the quantified PSOE used to correct the torque transient.

The study delves into PSOE faults and their correction transients using linear and non-linear system analysis. It further identifies torque output disturbances post-PSOE correction. Disturbance rejection and input modification control strategies are mathematically employed to address these issues. The research culminates in a comprehensive analysis of PSOE disturbance characteristics, methods to mitigate PSOE fault correction transients, and an approach to minimize transients during PSOE events. Comprehensive simulations substantiate the performance of each technique, encapsulated in a detailed project report enriched with analysis, simulation data, and MATLAB codes.

The devised and proposed method is invaluable for safety-critical applications, including electric vehicles, and high-efficiency applications like wind turbines, robotics, and automation. This method ensures both the safety and optimal control of the PMSM.

Keywords: Permanent Magnet Synchronous Machines, Position Sensor Offset Error, Field-Oriented Control, current controllers, disturbance rejection, input modification control, torque transient, transient suppression, estimation strategies.

Multispectral Imaging for Condition Monitoring

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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 condition monitoring. Using multispectral imaging, the spectrum associated with each pixel in a substance 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 types of technology for condition monitoring.

As the first part of this project, two case studies were conducted to estimate the adulteration level in coconut oil adulterated with palm oil and the adulteration level in turmeric adulterated with colored flour. Then the analysis was extended to estimate the aflatoxin levels in food products and to estimate the dry rubber content in latex. Furthermore, a method was developed to estimate the chlorophyll levels in lake water using satellite MSI images.

To begin with the processing, obtained data sets undergo a dimensionality reduction step using algorithms such as Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA). Then classifier models were developed using Support Vector Machines (SVM), *K*-Nearest Neighbors (KNN), Decision tree, and Logistic Regression. As the final step, functional mappings were obtained using Bhattacharya distance and Kullback-Liebler divergence.

Keywords: Multispectral imaging, spectral information, signal processing, image processing, dimension reduction, machine learning, classification, regression, statistical parameters.

Implementing an Intrusion Detection System for Software Defined Networks using Artificial Intelligence

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This study presents an artificial intelligence (AI)-based intrusion detection system (IDS) for software-defined networks (SDNs). The IDS uses machine learning and deep learning algorithms to detect known and unknown attacks, while preserving data privacy.

The research involved developing machine learning and deep learning models to detect the attack types of DoS, DDoS, BOTNET, BFA, Probe, U2R, and Web-attack. Initially, state of the art machine learning based classification models were trained on publicly available SDN intrusion detection dataset for the purpose of identifying the most suitable model for the defined application. Out of the tested models, the XGBoost algorithm achieved the highest accuracy of 99.9%.

Next, research was extended to develop anomaly-based models, namely Isolation Forest and Autoencoder, to detect unknown attacks. A Generative Adversarial Network (GAN) model was used to generate synthetic data to secure data privacy of clients. The synthetic data was generated to match the statistical distribution of the original data, but without sensitive information. The synthetic data was then used to train the Isolation Forest and Autoencoder models.

The evaluation results showed that the proposed anomaly-based models were able to effectively detect unknown attacks. Additionally, the GAN model was able to generate synthetic data that was indistinguishable from the original data, while preserving data privacy. Overall, this study presents a promising approach to enhance cybersecurity in SDN networks through AI approaches. The proposed IDS can be deployed in real-world SDN networks to improve their cybersecurity posture.

Keywords: Artificial intelligence, machine learning, deep learning, cybersecurity, intrusion detection systems, software defined network, Generative Adversarial Network (GAN), data privacy, anomaly detection.

Cybersecurity of Power Grids

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Traditional energy billing systems have undergone a profound transformation, evolving into Advanced Metering Infrastructure (AMI) through the integration of smart meters. This evolution has ushered in an era of real-time, bidirectional communication between consumers and utility companies. AMI relies on intricate networks of smart meters, data concentrators, and utility centers, facilitated by Information and Communication Technology (ICT) within cyber-physical systems. Within this paradigm, smart meters in home area networks (HANs) continuously transmit energy consumption data to data concentrators, which subsequently relay the information to utility centers.

However, this technological advancement has also introduced significant cybersecurity challenges. Malicious intruders possess the capability to disrupt the normal flow of the system, potentially causing substantial financial losses and reputational damage to utility companies. Our research addresses this critical issue by simulating an AMI environment on the OmNet++ platform. The simulation focuses on cybersecurity protocols, including encryption, error handling, and collision avoidance.

Particularly, we investigate the impact of denial-of-service attacks, wherein compromised smart meters overwhelm the data concentrator with an excessive data rate. This influx of data leads to dropped messages and, ultimately, system failure. To comprehensively address this security concern, we developed an analytical model which provides valuable insights into the system's behaviour under varying attack scenarios, considering the number of compromised smart meters and attacker rates.

Through this vulnerability assessment, our research offers invaluable insights for utility companies, enhancing their ability to bolster the resilience of AMI systems against cyber threats. This study contributes a nuanced understanding of the vulnerabilities within AMI networks, serving as a foundational step toward safeguarding the integrity and functionality of these systems. Our findings are pivotal in ensuring the reliability of future smart grid technologies and fortifying the global energy infrastructure against cybersecurity threats.

Keywords: Advanced Metering Infrastructure, cyber-physical systems, Smart meters, data concentrators, utility centers, denial of service attacks, vulnerability assessment, analytical module, smart grid technologies.

Open-Source Solar PV Inverter

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The prominence of photovoltaic (PV) energy as a major mainstream power source is on the rise, underpinned by its sustainable and eco-friendly attributes. In the context of Sri Lanka, PV plants are integrated into the grid using imported inverters. However, the use of proprietary inverters presents a significant challenge: they lack the capacity to access the pre-implemented control functions. Consequently, this deficiency curtails the utility's ability to incorporate essential grid-supporting functionalities into these inverters, impeding optimal grid integration. This research initiative tackles this issue head-on by focusing on the development of a pioneering single-phase open-source solar PV inverter. The key innovation lies in its capability not only to access but also to modify crucial grid-supporting functions. By doing so, the project aims to empower the utility with the much-needed flexibility, enabling seamless integration of vital grid-supporting features into the inverters. The project takes a comprehensive approach, encompassing the design, precise hardware implementation, and rigorous testing of both the solar PV inverter and the associated boost converter. Notably, the inverter is designed as a smart device, which elevates its functionality manifold. This intelligence allows for the integration of diverse Maximum Power Point Tracking (MPPT) algorithms, active power control functions, and reactive power control functions within the boost converter and the inverter respectively, further enhancing its capabilities. In conclusion, this research not only addresses a critical gap in the PV integration landscape but also sets the stage for a more efficient, sustainable, and adaptable energy sector.

Keywords: photovoltaic, control functions, smart device, Maximum Power Point Tracking, active power, reactive power

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Patient Clustering and Event Monitoring Based on Electronic Medical Records

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In recent decades, navigation technology has advanced rapidly, yet understanding Chronic Kidney Disease of Unknown Origin (CKDU) remains a complex puzzle. CKDU confuses researchers due to uncertain risk factors and causes. This project aims to create a CKDU recognition system and identify the most significant risk factors.

This analysis centers on a comprehensive dataset encompassing patients in all five stages of CKDU. The dataset includes biopsy-confirmed CKDU patients from endemic areas, along with data from people with Chronic Kidney Disease in endemic areas (ECKD), control subjects from endemic areas (EC), non-endemic area control subjects (NEC), and non-endemic area Chronic Kidney Disease patients (NECKD).The dataset comprises a rich array of 32 trace elements, environmental factors, and lifestyle choices, complemented by serum and urine data. Utilizing machine learning techniques, the feature space has been effectively reduced to 10 significant attributes, and further refinement has been carried out to identify just 3 features using neural networks. Notably, perfect separation between non-endemic groups (NEC and NECKD) and the endemic CKDU population has been achieved with 100% accuracy using neural network models. Additionally, a similar degree of accuracy has been accomplished in distinguishing CKDU patients from EC and ECKD subjects, with just three key features. To facilitate the utilization of the findings, a user-friendly Graphical User Interface (GUI) has been developed, allowing the exploration of the separation of different groups using their choice of selected features. Furthermore, an intuitive webpage has been designed for the deployment of the machine learning model to provide real-time predictions.

Different groups of patients and controls can be accurately separated. This enables the disease to be diagnosed more effectively, eliminating the need for complex tests.

Keywords: CKDU, endemic, endemic control, biopsy, chronic.

Arc-Fault Circuit Interrupter

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Electrical arc faults represent a significant hazard in the modern electrical infrastructure, capable of causing devastating fires and endangering lives. This project is committed to creating an advanced solution for the early detection and prevention of arc faults within electrical circuits. The objectives encompass the design and implementation of a highly accurate classification system model, real-time monitoring, cost-effectiveness, and a comprehensive development process.

The project initiates the collection of data that simulates various arc fault scenarios, followed by meticulous preprocessing and feature extraction to obtain critical insights from the collected information. Feature selection ensures that only the most relevant parameters are considered for analysis. Subsequently, a state-of-the-art classification model is chosen, trained, and evaluated using the collected data.

A key focus of this project is the real-time monitoring and detection of arc faults, providing timely alerts and intervention. To achieve cost-effectiveness, the project seeks to balance high performance with practicality, ensuring that the final solution can be readily implemented in electrical systems.

Deliverables include an initial circuit design, an arc current generator prototype, and a computer-based model for recognizing arcs, all culminating in a completed circuit with built-in arc-fault protection. The project acknowledges the necessity for continuous monitoring and updates to adapt to evolving arc fault patterns and improve overall safety.

By developing this innovative Arc-Fault Circuit Interrupter, the project aims to revolutionize electrical safety, significantly reducing the risks associated with arc faults and preventing potential electrical fires. This endeavor represents a crucial step towards a safer and more secure electrical infrastructure for homes and businesses alike.

Keywords: Arc-fault circuit interrupter, early detection, electrical arc faults, real-time monitoring.

Collective and Coordinated Mitigation of Distributed Harmonics using Grid Tie Inverters

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The integration of renewable energy sources, such as solar and wind power, into the modern power grid has led to significant advancements in energy sustainability. However, it has also introduced new challenges, including the emergence of harmonics in distributed power systems. Harmonics, which are unwanted, non-sinusoidal components of electrical signals, can negatively impact the quality and stability of the grid.

This project addresses the pressing need for efficient and cost-effective mitigation of distributed harmonics by leveraging the capabilities of grid-tie inverters. Employing the IEEE 69 bus system as the model, our research initially injected nonlinear loads into the network to assess voltage and current Total Harmonic Distortion (THD) values. Subsequently, shunt active filters were strategically installed in parallel to the nonlinear loads and at selected locations to evaluate the efficacy of harmonic reduction. The rationale behind the selection of shunt active power filters was their structural similarity to grid tie inverters, indicating the potential for grid tie inverters to function effectively as harmonic filters. These inverters exhibited proficiency in attenuating current harmonics. Building on this understanding, the conventional system was then replaced with grid tie inverters connected to solar panels, revealing a marked reduction in harmonic content. Drawing from this observation, a distributed control scheme for grid tie inverters will be proposed, enabling them to switch between their primary function of power inversion and an auxiliary role as effective harmonic filters. The anticipated outcomes of this study include improved power quality, enhanced grid resilience, and optimized utilization of renewable energy resources.

Keywords: IEEE 69 bus system, nonlinear loads, THD, shunt active filter, grid tie inverter, solar panels, grid resilience, renewable energy resources.

Clustering Nodes in a Wireless Mobile Network for Traffic Prediction

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As telecommunications networks become widespread, properly predicting network behavior plays a vital role in optimizing mobile and fixed network services. Therefore, traffic prediction has become crucial for network providers.

This endeavor aims to explore the application of clustering techniques to enhance traffic prediction within wireless mobile networks. By grouping network nodes based on shared characteristics and leveraging machine learning and predictive modeling within these clusters, our study aims to provide more precise and actionable insights into network behavior and performance. We present a comprehensive methodology, encompassing data collection, preprocessing, clustering and predictive model development.

An accurate prediction is essential for most network management tasks, such as resource allocation, short-time traffic scheduling, long-term capacity planning, network design, and network anomaly detection. Also, it allows network providers to optimize network resource allocation, potentially improving the quality of service and helping detect malicious attacks in the network and ultimately leading to improved network efficiency and user experience.

Keywords: Telecommunication network, traffic analysis, clustering, prediction.

Action Prediction of Wild Elephants Using Vision Based Deep Learning

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Human-elephant conflicts in regions of shared habitats demand innovative solutions. We present an automated Elephant Detection System using Vision-Based Deep Learning, aimed at detecting elephants and classifying behavior, particularly identifying aggressive individuals within herds.

Our methodology involved creating a diverse dataset of elephant behaviors from wildlife databases and field observations. Data preprocessing techniques included resizing, augmentation and standardizing the dataset. Bounding box annotations were used, introducing "Aggressive Tail" and "Aggressive Ear" classes for aggressive behavior classification.

The vision-based deep learning approach combined with YOLOv5 was adapted for elephant detection and a custom model was developed for aggressive behavior classification. The system followed a two-step process, first detecting the elephants and then analyzing cropped regions to classify the aggressive behaviors. This approach significantly improved accuracy and efficiency.

Testing on various video streams on elephant behaviors demonstrated that the Elephant Detection System is substantially accurate and capable of executing it in real-time. It generates alerts for aggressive elephant behaviors in high-risk areas, contributing to human-elephant conflict mitigation.

This project advances the field by combining deep learning and wildlife conservation. Continued refinement holds potential for broader impact in coexistence strategies. In conclusion, our Elephant Detection System contributes to coexistence efforts, leveraging vision-based deep learning for effective elephant detection and aggressive behavior classification. It is poised to drive harmonious human-elephant coexistence in conflict-prone regions.

Keywords: Human-elephant conflict, aggressive elephant detection, YOLOv5, vision-based deep learning.

Deep Learning Based Human Detection System for Search and Rescue

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Search and rescue operations in disaster-stricken areas are critical endeavors that demand efficient, timely, and life-saving solutions. Traditional search and rescue techniques can be time-consuming and labor-intensive, often hampered by challenging environmental conditions.

Locating lost persons or victims who may be unconscious or injured as quickly as possible is critical to improving their chances of survival. However, accessing remote and hostile environments on foot for search and rescue is time-consuming.

Unmanned aerial vehicles, more commonly known as drones, have the potential to cover larger geographical areas in a shorter time span. UAVs equipped with high-resolution cameras and embedded GPUs are powerful enough to capture terrain details and provide a bird's-eye view of movements in remote and hostile environments with reduced manpower requirements. In turn, UAVs could assist the search and rescue (SAR) teams in successfully conducting rescue operations in constrained environments while reducing rescue time.

In this project, we evaluate the potential of using state-of-the-art deep learning models, YOLOv7 and SSD-MobileNet architectures, for UAV-based search and rescue (SAR) operations. To achieve this, we custom-created a sample UAV image dataset with annotations of people. Transfer learning is utilized to fine-tune the two models, and their performance is compared using accuracy in detection.

Keywords: Search and Rescue, Unmanned Aerial Vehicle, drones, deep learning.

A 3D Dynamic Model for the Study of Quadruped Locomotion

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In recent years, the field of robotics has witnessed remarkable advancements, particularly in the domain of locomotion. Here, we introduce a 3D dynamic model, to study the locomotion of quadrupeds, in this case, a cat. This model will be implemented within the open-source WEBOTS computer simulation environment.

The core of this project revolves around the concept of Central Pattern Generators (CPGs), which will serve as the foundational mechanism for generating the rhythmic movements of the quadruped locomotion. CPGs will be implemented through a network of non-linear mathematical oscillators or piecewise time-driven functions, replicating the rhythmic and coordinated movements observed in quadrupedal locomotion. To enhance the model's realism and adaptability, sensory information will be a pivotal component. The system will be equipped with contact and force sensors and joint angle detectors, enabling it to interact with its environment and adjust its locomotor patterns accordingly. Furthermore, the project will explore the inclusion of a muscle model, striving to mimic the physiological intricacies of a real quadruped muscular system.

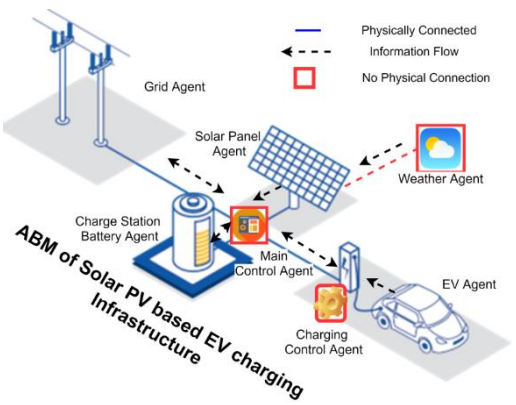
By combining theoretical understanding in neurophysiology, biomechanics, and behavioral studies with practical implementation in “silico”, this project opens up exciting possibilities for investigating the neural control mechanisms in quadrupedal locomotion, with potential applications ranging from robotic systems to biomechanical studies.

Keywords: Quadruped locomotion, dynamic model, central pattern generators, non-linear mathematical oscillators, sensory-motor integration, biomechanics, robotic gait generation, dynamic movement patterns and robotic control systems.

POSTGRADUATE RESEARCH PROJECTS

Agent-Based Model (ABM) of Solar-Based EV Charging Station on the University Premises

S.K. Jaslin
Supervised by: Dr. M.A.U.S. Navaratne, Prof. J.B. Ekanayake



The Electric Vehicle (EV) population around the world is increasing exponentially and capturing the automobile market share as of 2023. With the recent economic changes and government plan Sri Lanka is also encouraging the use of EVs instead of gasoline vehicles. In Sri Lanka as well as around the globe significant portion of university staff and students travel to the universities in their own vehicles. The use of EVs rather than gasoline vehicles in the university community can help to reduce carbon-based energy consumption and associated environmental pollution. This research investigates the effect of using more and more EVs in a university community and how universities can design the corresponding infrastructure such as charging stations. Solar Photovoltaic (PV) based charging infrastructure is investigated to minimize carbon-based energy utilization. This research analyzes the complexity of the EV movements, charging and discharging patterns, the intermittent nature of the corresponding PV energy sources, etc. The research investigates two methods for modeling and analyzing the EV infrastructure namely, stochastic model and Agent-Based Model (ABM). The first method uses mathematical modeling based on the stochastic nature of the PVs and EVs. After analyzing the complexity of the first model the research introduces ABM techniques to model the complex EV infrastructure. Using the ABM model this research investigates the behavior of the system under different charging modes such as uncontrolled, V2G, G2V, and G2V-slow charging when the State of Charge (SoC) based flat tariff and Time of Use (ToU) tariff is utilized with slow, average and fast charging modes.

Deep Generative Adversarial Network Method for Improving the Readability of Epigraphy

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A key source of ancient history is the discipline of epigraphy, which provides direct evidence of the attitudes, thoughts, and cultural history of ancient civilizations. The study of "inscriptions" written on a persistent surface (stone, ceramic, clay, metal) by an individual or group in the past, can be identified as Epigraphy. In Sri Lanka's 2500-year history, numerous stone inscriptions hold historical secrets, but many have eroded over time. Archeologists face challenges in reading these ancient texts as weathering has extensively damaged parts of the characters and inscriptions, rendering them difficult to interpret.

Hence this study introduced a learning-based approach using a UNet GAN model to restore unreadable characters in inscriptions. The model's generator, based on U-Net architecture, employs eight down sampling and seven up sampling layers. The generator loss is determined by the sigmoid cross-entropy loss of generated images, while the discriminator loss compares output of generator to ground truth images (non-deformed characters). The high-res images of inscription characters were captured and around 2,000 character images across different deformation levels were created as the dataset of this research. After training, the U-Net GAN architecture for 20000 iterations, it was able to correct the deformed characters to an acceptable level of accuracy as shown in Fig 1.

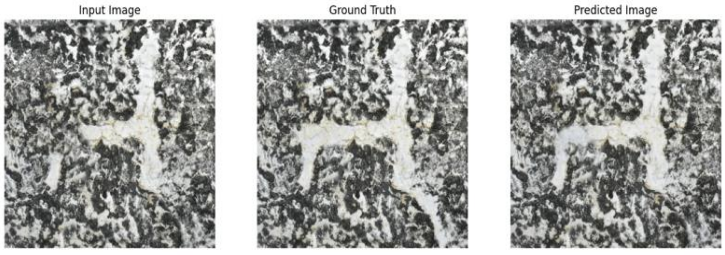

Fig. 1: Deformed image given as the input image (a), ground truth (b) The recovered image from the model (c)

Keywords: Machine learning, Generative Adversarial Networks, deep learning, image denoising.

Investigate the Potential for Floating PV Systems with Mahaweli Major Reservoirs

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Solar energy is a “green source of energy” can be harnessed from the power and heat of the sun’s rays. Solar Photovoltaic (PV) system, which convert the energy in sunlight to electrical energy, is anticipated to become the world's largest source of electricity. However, allocating a land to implement large-scale PV system can be challenge due to the large area required. This challenge can be overcome by implementing floating solar systems. The floating PV system not only generates electricity but also reduces water evaporation. Floating PV system generates more electricity in dry season when hydro power output is less which is another advantage. Mahaweli reservoir system consists of eleven reservoirs which are distributed in the central part of Sri Lanka. These reservoirs provide water for irrigation projects as well as produce electricity, thus acting as hydro power plants. These reservoirs cover a large area and are very suitable for floating PV systems.

The weather data of the reservoirs were available through the measuring instruments for a period of one year at an interval of one minute on eight major reservoirs. The potential PV generation was estimated using the weather data. Furthermore, daily, monthly, and annual energy generation was estimated. The potential for floating PV systems, implemented near the perimeter of the reservoirs as floating PV systems, was evaluated. The analysis found that a PV system with five rows can implement a 253.64 MW floating PV system. The potential annual average energy generation is 361.30 GWh.

Stagnant Water Detection from Aerial Imagery Using Computer Vision

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Efficient and precise identification of water bodies in aerial images holds substantial value across a spectrum of applications, including environmental monitoring, urban planning, and emergency responses to natural disasters. Traditional methods for extracting stagnant water bodies grapple with challenges related to selecting suitable image textures and features, as well as contending with interference from shadows cast by buildings and ground objects that share similar spectral characteristics with water bodies. This paper introduces an innovative deep-learning network designed for the identification of stagnant water in aerial images. Drawing inspiration from the SegNet architecture and incorporating attention mechanisms, the proposed model integrates three key components: a shadow attention unit, a spatial attention unit, and a channel attention unit. These elements collectively enhance the model's precision in predicting water areas. The shadow attention module is precisely engineered to detect shadows on water surfaces, while the spatial and channel attention modules enable the model to focus on pertinent objects while reducing background noise. In comparison to the standard SegNet model, the proposed model yields substantial improvements in the accurate prediction of water areas. It achieves an 11.6% boost in the Dice score for stagnant water prediction. This outcome underscores the efficacy of the proposed model in precisely identifying stagnant water regions in aerial images. The resulting output of the proposed model is depicted in Figure 1.

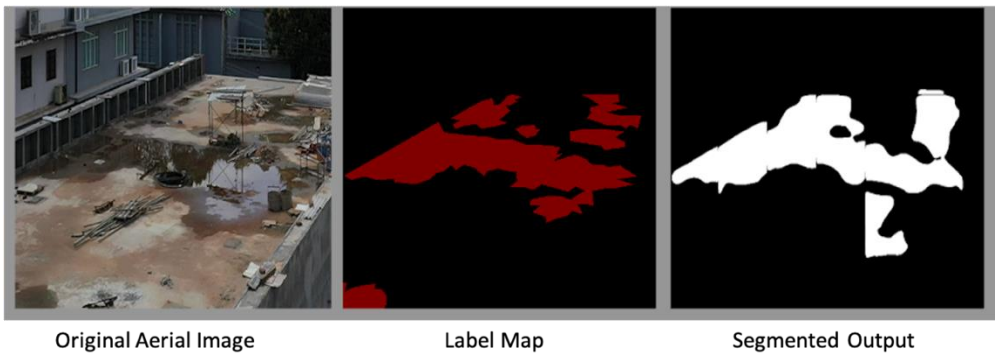

Fig. 1: Segmented output from the proposed model

Keywords: Unmanned Aerial Vehicle, drones, deep learning

A Technical Insight and Performance Analysis of Vehicle Electrification in Comparison to Internal Combustion Engine Vehicles

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Supervised by: Prof. Lilantha Samaranayake

In recent years, there has been a growing interest in understanding the technical aspects and performance differences between EVs and conventional vehicles. This study focuses on discussing a comprehensive background on the technical insight and performance analysis of an EV compared to a conventional vehicle, focusing on key factors such as motor speed, engine speed, torque-speed characteristics, fuel economy (FE), and emission of air pollutants based on the components of the EV system using a simulation model of an EV on the MATLAB-Simulink platform. Additionally, the relevant electrical system components and their corresponding equations for verification were identified. The simulation results related to the designed EV model were compared to those of a conventional vehicle model, which gets its motive power from an internal combustion engine (ICE). From the comparison, it was evident that even though the ICE vehicle fuel tank had less weight compared to the battery of the EV, the EV model was more efficient with its FE. Also, the results of the simulation showed that EVs are more energy efficient compared to ICE vehicles.

Referring to the results, at the maximum trace velocity of around 60 mph, the EV motor speed was approximately 3 times that of the ICE vehicle. Also, even though the motor speed goes up to approximately 1.5 times the engine speed of an ICE-driven vehicle. When the drive cycle signal reached 0 mph, both the engine speed of the ICE and the motor speed of the EV were 0 rpm. Also, for the same trace velocity, the FE for hybrid EVs was 5.74 times that of ICE vehicles. In this project, when comparing the weight of the ICE of the conventional vehicle with the battery of an EV, the specifications of a commercially available petrol ICE TATA Tiago car and its electrified TATA Tiago versions are used. The calculation showed that the weight of the EV was approximately 3 times heavier than the ICE to travel 665 km, where the ICE vehicle was traveling with full-tanked fuel while traveling the same distance in a single charge of the EV. The results of this study will provide a solid foundation for further research in this field. The results of this study will provide a solid foundation for further research in this field.

Towards Safer Night-Time Driving: Enhancing Night-Time Visibility Using Deep Learning-Based Image Translation

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Ensuring driving safety at night with limited ambient light is crucial. Even though conventional methods like gamma correction have limitations, modern deep learning techniques like VAEs and GANs can promise improved visibility. The research focuses on enhancing night-time visibility using GANs for night-to-day image translation. A novel generator network is developed which can be trained with both supervised and unsupervised GAN models. Pix2Pix was used as the supervised model with the proposed generator and the Cycle-GAN model was used as the unsupervised model with the proposed generator. Supervised training provided an average improvement of 16.32 dB in Peak-Signal to Noise Ratio (PSNR), 0.513 in Structural Similarity Index (SSIM), and a significant average reduction of 67.33 in Fréchet Inception Distance (FID). Similarly, Unsupervised training provided substantial enhancements of 8% in IS, 2% in Natural Image Quality Evaluator (NIQE), and 13% in Blind Referenceless Image Spatial Quality Evaluator (BRISQUE) scores.

Fig. 1: Comparison of sample images generated by Cycle-GAN and Cycle-GAN with the proposed generator (B – BRISQUE Score, N – NIQE Score)

Fig. 2: Comparison of sample images generated by Pix2Pix and Pix2Pix with the proposed generator (P – PSNR Score, S – SSIM Score, F – FID Score)

Keywords: Generative Adversarial Networks, night-driving, safety, image-translation, low-light.

Assessment and Mitigation of the Harmonic Distortion in a Distribution Network Caused by the distributed small-scale industrial & Residential Loads

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Abstract— Harmonics of the voltage and current have been existing in power systems for many years. In the past, most of the electrical equipment used was balanced and linear load. In the recent past, the nonlinear loads in industrial plants have been increasing rapidly and the percentage of these loads becomes higher. Accordingly, the effects of harmonics within the electrical system and their impact on the electric utility and neighbouring plants should be examined to avoid equipment damage and subsequent plant shutdowns. there had been rapid growth in electricity demand from the industrial loads[1], specially in various types of small-scale production industries connected to local distribution network . This project is focused to discuss on the analysis of harmonic disturbances in the electrical distribution system of the. North Western Province (NWP) due to residential and small-scale production plants. Medium-scale production plants (below 95kVA) connected to distribution substations were used to demonstrate that the harmonic levels present in our distribution system are approaching the limits specified in IEEE 519 international standard [2]. The mitigation technics that we can be adopted to the system are also presented and discussed in this paper.

I. INTRODUCTION

Harmonic currents are present in modern electrical distribution systems caused by non-linear loads such as adjustable speed drives; induction motors; electronically ballasted lighting; and the power supplies of every computer, copier, and fax machine and much of the telecom equipment used in modern offices. The widespread and growing of these loads has greatly increased the flow of harmonic currents on facility distribution systems and has created many problems. These problems include overheated transformers, motors, conductors, and neutral wires; nuisance breaker trips; voltage distortion, which can cause sensitive electronic equipment to malfunction or fail; and elevated neutral-to-ground voltage, which can cause local area networks to malfunction

The main objective of this study is to identify the potential customers that can cause the harmonic injection to the distribution system by taking the measurements from several selected transformers to propose methods to mitigate the harmonics in the distribution network of Sri Lanka.

II. HARMONIC ANALYSIS

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A. Field Measurements

Measurements were carried out on site to investigate the harmonic pollution level of the selected transformers and taken all the measurements at the transformer LV bushing. A Digital Power Quality Analyser was used to record the Voltage, Current, THD_V, THD_I and all the harmonic components up to 15^{th}. Those measurements were taken from 6.45 AM to 12.45 PM in 5 min intervals on a weekday

a. Case 1

The power quality analyser recorded the set of parameters and table I shows some of the recorded parameters including THD_I, THD_V.

TABLE I. RECORDED THD_V &THD_I FROM POWER QUALITY ANALYZER

Parameter	Phase A	Phase B	Phase C
Active power AVG (W)	59905.16	55762.07	54054.38
Reactive Power AVG (VAr)	23676.03	23754.54	24627.9
Apparent Power AVG (VA)	64414.15	60610.95	59400.42
Power Factor AVG	0.93	0.92	0.91
Vrms ph-n AN Avg	228.5	229.5	229.7
Current Avg	281.9	264.1	258.6
THD I %	21.56	20.25	19.7
THD V %	2.91	3.29	3.06
TDD %	35.8	33.7	32.8
3rd Harmonic I	16.34	16.09	13.22
5th Harmonic I	24.2	24.02	19.24
7th Harmonic I	12.03	12.03	10.38
9th Harmonic I	9.66	9.59	8.44
11th Harmonic I	8.21	8.12	7.21
13th Harmonic I	6.89	6.82	6.21

The Graph of the $THD_{I\text{-}123}$ vs. Time By using above-measured data, harmonic spectrum, TDD against the Time is shown in Fig 1 & 2

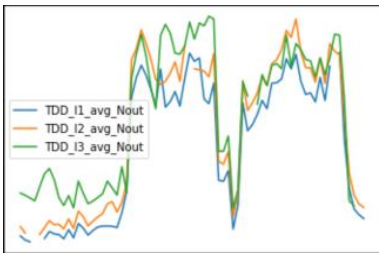

Fig.1 The Graph of the $TDD_{I\text{-}123}$ Vs Time

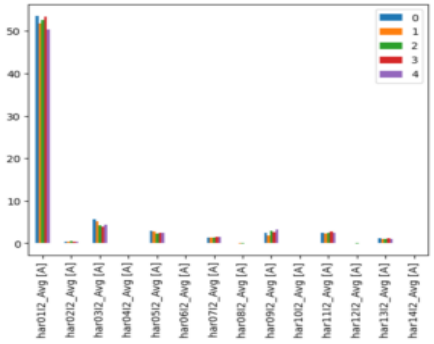

Fig.2 Current Harmonic Spectrum

B. Simulation Results

Simulations were carried out by Using OPENDSS software, to obtain the voltage and current pollution at Transformer bushing which is the Point of Common Coupling (PCC).the simulated results of THD values and spectrum is shown in fig. 3

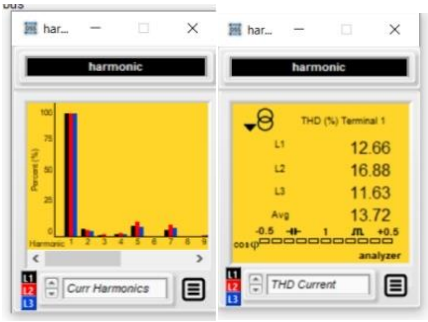

Fig.3 Current harmonic spectrum and THD Values

The above simulation results show the current harmonic distortion of the modelled system (for case I) and it is clear that these results are close to actual measurements. Accordingly, this modelled system can be used to this case study.

III. HARMONIC FILTER DESIGN

A shunt passive filter for compensation the 3rd, 5th and 7th orders of harmonics in particular distribution feeder. Assuming that Filter branches equally contributes to the power factor correction. Table III shows the parameter values of the filter.

TABLE III. CALCULATED VALUES FOR FILTER COMPONENTS

Filter components	3rd harmonic filter branch	5th harmonic filter branch	7th harmonic filter branch
C (□F)	97.32	97.32	97.32
X (□)	10.89	6.53	4.67
L (H)	0.0115	0.0041	0.0021
R (□)	0.218	0.131	0.093

The simulation results with the designed filter shows the values of the THD currents and current harmonic spectrum in the fig. 4

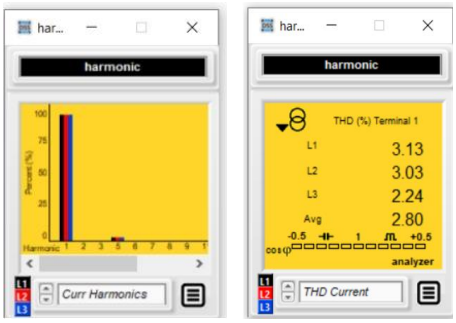

Fig.4 Current harmonic spectrum and THD Values with a filter

IV. CONCLUSIONS

This paper presents a study into harmonic pollution in the part of the LV Distribution Network in the North Western Province of Sri Lanka. Accordingly, an investigation of harmonics present in the voltage and current waveforms of low voltage distribution network is conducted with an objective to know the existing level of harmonic distortion present in the low voltage distribution network of north western province and future trends. Harmonics injected by some very commonly used nonlinear loads are studied. It is observed that significant distortion in the current exists due to the use of 3 phase induction motors, Computers with UPSs and other electronic equipment in residential and commercial consumers. Increasing use of these equipment may result in serious problems in near future. The current distortion differs widely from one section to the next. Although, voltage distortion is recorded below the acceptable limit, but it can be exceeded the recommended limit at the places of high current distortion, as it depends on the circuit impedance as well as harmonic generation characteristics.

Therefore, Utility must be given the careful considerations when connecting the new loads to the existing LV Network. Not only for the rooftop PV connections, but all other middle level industries connected to the LV network should be taken into account.

ACKNOWLEDGMENT

I would like to express my sincere gratitude to my supervisor Dr. M.A.U.S. Navaratna and all the Academic and Non-Academic staff of the Faculty of Electrical and Electronic Engineering, University of Peradeniya Sri Lanka. As well as all the technical staff of CEB who gave the support to success this research.

REFERENCES

[1] C.J. Gajanayake, G. Ramtharan, G.K. Samaraweera, A. Atputharajah, J.B. ekanayake," A Survey of Harmonic Currents at Several Industries in Sri Lanka.

[2] IEEE Std 519, Recommended practice and requirements for harmonics control in electrical power systems, ANSI/ IEEE, 2022

Performances Analysis of Semi-Indirect Metering System under the Influence of Harmonics

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Abstract— The introduction of non-linear loads where the current waveform does not comply with the applied voltage waveform has caused the propagation of power system harmonics to a great extent. Presence of harmonic leads to overheating of conductors, transformers, hbhbh equipment such as motors, and capacitor bank failure. Another significant, but least considered spot which is affected by the power system harmonic is the energy meter installed at the common coupling point of consumers.

I. Introduction

Performance review of energy meters under the influence of harmonics has become a necessity with nonlinear load spreading at the domestic level and the industry. Thus, it is vital to get confirmation whether the measurement error of installed meters is within the specified levels of accuracy as per the applicable standards. Generally, electricity metering can be classified as Direct metering, Semi-indirect metering & Indirect metering. This research findings reveal a significant impact of harmonics on secondary circuits equipped with electronic meters in semi-indirect metering systems,

II. Semi Indirect Metering System

Generally, the semi-indirect metering system consists of an energy meter and a current transformer. Therefore, the overall accuracy of the system will be the combination of both error of energy meter and current transformer.

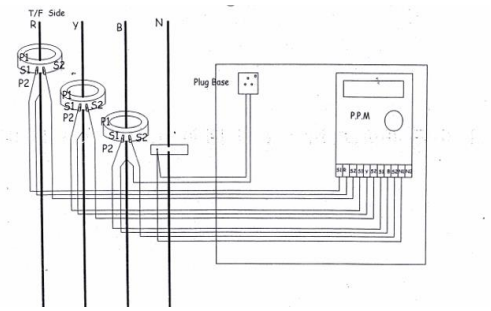

Fig. 1 Wiring Diagram of Indirect Metering System

III. Theoretical Overview

A. *Energy measurement at harmonic environment*

Non-sinusoidal instantaneous voltage or current has two distinctive components: the power system frequency components v_1 and i_1, and the remaining terms v_H and i_H that contains all integer and non- integer number harmonics.

$$v_1 = \sqrt{2}\,V_1 \sin(\omega t \alpha_1) \quad (1)$$

$$i_1 = \sqrt{2}\,I_1 \sin(\omega t \beta_1) \quad (2)$$

$$v_H = \sqrt{2}\sum_{h\neq 1}^{n} V_h \sin(h\omega t - \alpha_h) \quad (3)$$

$$i_H = \sqrt{2}\sum_{h\neq 1}^{n} I_h \sin(h\omega t - \beta_h) \quad (4)$$

$$THD_v = \frac{V_H}{V_1}\sqrt{\left(\frac{V}{V_1}\right)^2 - 1} \quad (5)$$

$$THD_I = \frac{I_H}{I_1} = \sqrt{\left(\frac{I}{I_1}\right)^2 - 1} \quad (6)$$

$$P = V_1 I_1 \cos\varphi_1 + \sum_{h\neq 1}^{n} V_h I_h \cos\varphi_h \quad (7)$$

Here V, I are rms quantities. Active power delivered by both fundamental and harmonics can be derived as; equation [7].

B. Behaviour of energy meter under the influence of harmonics

Errors in energy measurement can occur due to various factors, including the true RMS measurement, sampling rate, and the technology of the meter. If the true RMS measurement is inaccurate, it can lead to errors in energy measurement. If the electrical waveform is not a pure sinusoid, the meter may not accurately capture the RMS value.

TABLE I
ERROR VARIATION OF ENERGY METER AGAINST CURRENT HARMONICS

I_n	PF = 1		PF =0.8		PF =0.5	
	E_{If}	E_{Ih}	E_{If}	E_{Ih}	E_{If}	E_{Ih}
10%	0.324	0.436	0.369	0.528	0.389	0.616
30%	0.316	0.429	0.361	0.508	0.371	0.595
50%	0.313	0.426	0.349	0.491	0.359	0.575
70%	0.311	0.422	0.345	0.478	0.358	0.559
90%	0.308	0.419	0.339	0.461	0.356	0.536
100%	0.307	0.418	0.336	0.451	0.354	0.531

E_{If} -Error at fundamental current
E_{If} - Error at current THD =20%

C. Behaviour of current transformer under the influence of harmonics

Operation of a current transformer at its designed voltage but at a higher frequency than intended will lead to reduced magnetizing current. At a lower frequency, the magnetizing current will increase. As the core saturates, its inductance decreases, and this can result in a reduction in the magnetizing current. The magnetizing current is inversely proportional to the inductance of the CT's primary winding, and with early saturation, the inductance decreases, causing the magnetizing current to be lower than it would be in the absence of harmonics.

IV. LABORATORY SETUP

A laboratory practical simulation was carried out to evaluate the performances of 100/5 semi-indirect metering models. ZERA made three-phase stationary test standards were used. It consists of the individually controlled current source, voltage source and integrated harmonic generated up to 40th harmonic with accuracy of 0.02. Schematic diagram of the test setup is illustrated in Figure 2.

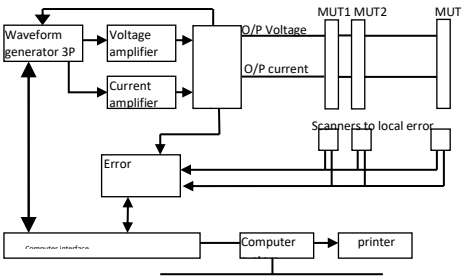

Figure2. Schematic diagram of testing setup

A. *Behaviour of the overall system under the influence of harmonics*

Based on the surveyed data, it has been determined that voltage harmonics do not significantly affect the accuracy of energy metering. Consequently, all simulations and analyses were focused exclusively on current harmonics

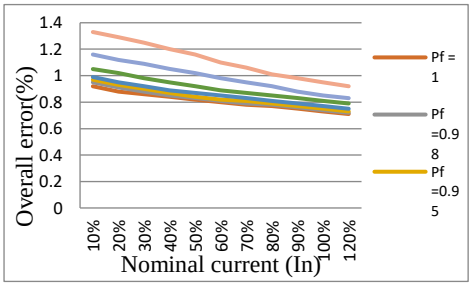

Fig. 3 Error variation of the semi-indirect metering system without the influence of current harmonic

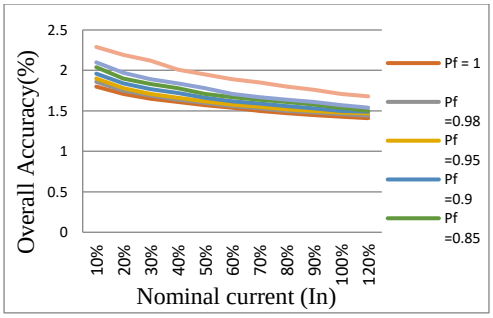

Fig. 4 Error variation of the semi-indirect metering system under the influence of current harmonic (THD=20%)

Several tabulations were carried out to analyse the behaviour of the Semi -Indirect Metering system under the influence of harmonics. The observations of the above experiment are power factor, nominal current, and *current harmonic distortion* effectively changed the overall accuracy of the Semi-Indirect metering system. However, the accuracy deviation of the total metering system is moved toward the positive side

V. CONCLUSIONS

One of the major findings derived from this research is that the secondary circuits equipped with electronic meters are affected by the influence of harmonics. In this research, it was noticed that the odd current harmonics are critically affected for the accuracy of the current transformer as well as the accuracy of the energy meter.

Implementation of a Power Prediction Model for a RISC-V Processor

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The Instruction Set Architecture (ISA) of a computer defines the fundamental operations and instructions that it can support. RISC-V computer architecture is an open-source ISA based on the Reduced Instruction Set Computer (RISC) principle. In comparison to other proprietary complex architectures such as x86 and ARM, the ISA of RISC-V is relatively compact and simple. Hence RISC-V has gained noticeable traction among chip manufacturers in recent years. As a result, there is an emerging trend for developing comprehensive frameworks that are compatible with RISC-V to perform the Power, Performance, and Area (PPA) analysis at the early stages of the chip manufacturing process. This paper presents an implementation of a linear regression power model for a RISC-V processor that can predict the power profile based on the instruction execution. For this experiment, a simple RISC-V processor that supports a minimalized set of instructions was developed. This processor includes basic processor features like forwarding, bypassing, hazard detection, stalling, pipelining, dynamic branch prediction, and memory caching. Figure 1 illustrate the main components of the processor design.

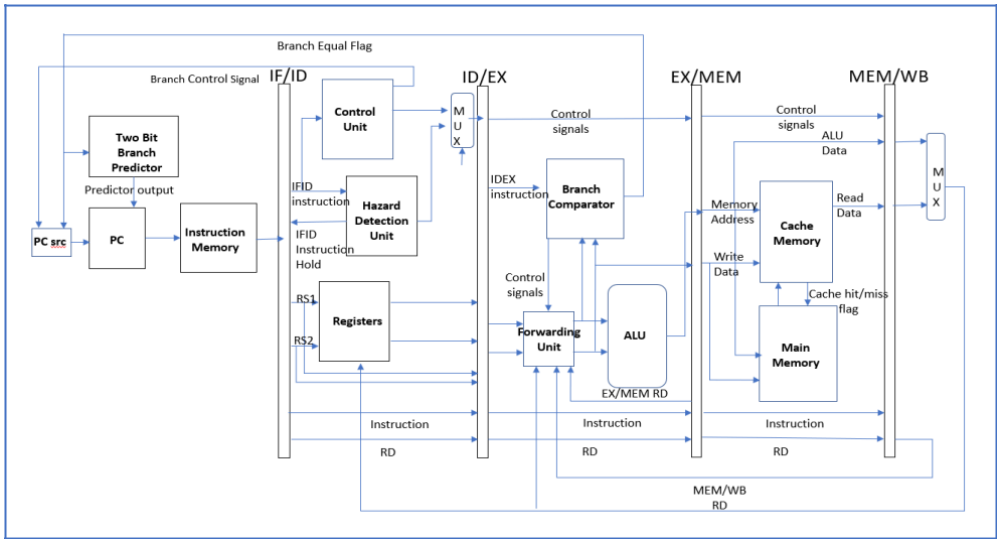

Fig. 1: The Main Components of the Pipelined Processor design

The processor is verified using the VCS simulator and the same simulation output was used in the later stage to generate the training data set for the power prediction ML module. The implemented empirical power predictive module considers simulation waveforms of design-essential nets (including primary

input/output nets, high fanout register output nets, memory cell output nets, black-box cell output cells, etc.) and architecture-critical nets (hazard detection flags, branch misprediction flag, memory cache miss flag, etc.) as the independent variables. In order to evaluate the accuracy of the model, the predicted power numbers were compared against the power numbers generated from the Spyglass Power Estimation tool. The implemented model has demonstrated a significantly low Root Mean Squared Error (RMSE) which was observed as 0.35.

Key words: Instruction set architecture, RISC-V, processor implementation, power predictive mode


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