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Abstract Index

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Comparative Analysis of Charge Recombination Dynamics in Dye-Sensitized Solar Cells with Different Counter Electrodes

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Counter electrodes are essential in dye-sensitized solar cells (DSSCs) for facilitating charge transfer and catalyzing the regeneration of the electrolyte, impacting overall efficiency. Common counter-electrode materials include platinum (Pt), poly(3,4-ethylenedioxythiophene): polystyrene sulfonate (PEDOT:PSS), and graphene, each with distinct advantages and challenges. Pt, a traditional choice, offers excellent catalytic activity but is limited by its high cost and scarcity. PEDOT:PSS, a conductive polymer, is cost-effective and easily deposited but often suffers from high recombination losses and lower efficiency. Graphene, known for its high conductivity and large surface area, is emerging as a promising alternative. However, a lack of comparative studies on how different counter-electrode materials influence recombination dynamics limits the understanding needed for optimizing DSSC performance. This study addresses this gap by examining Pt, graphene, and PEDOT:PSS-based counter electrodes, analyzing their effects on charge transfer, recombination behavior, and efficiency through current density-voltage (J-V) measurements, charge extraction, and transient photocurrent (TPC) as well as transient photovoltage (TPV) analyses. Graphene-based DSSCs show superior performance, achieving the highest photocurrent density and power conversion efficiency up to 5.12% at an intensity equivalent to 1 sun (100 $mWcm^{-2}$) due to enhanced charge extraction and minimized recombination. TPC data reveal that graphene supports faster charge transport, while TPV analysis shows longer electron lifetimes than PEDOT:PSS-based DSSCs. In contrast, PEDOT:PSS-based DSSCs exhibit high recombination losses, lower photocurrent, and s-shaped J-V curves, indicating high resistance of limited charge transfer efficiency. These findings highlight graphene's potential as an optimal counter-electrode material for efficient, high-performance DSSCs.

Keywords: Dye-sensitized solar cells, counter electrodes, recombination dynamics, graphene electrodes, charge extraction, PEDOT:PSS.

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Advanced State Estimations for Gravitational Oil/Water Separator Tanks using a Kalman Filter and Multi-Model Hypothesis Testing

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This paper presents a new application of the Kalman filter with hypothesis testing for a fast and robust model-based estimator for measuring level interfaces of atmospheric gravitational oil-water separator tanks. A newly developed semi-empirical linearized model is applied in the estimator algorithm. A multi-model hypothesis-testing algorithm for covering more scenarios was deployed. The proposed method provides a cost-effective and straightforward solution for estimating all state variables in an oil-water separator. Our evaluation results demonstrate that the proposed algorithm achieves high accuracy with an observation error of less than 2% and a false alarm rate of 3.3% under 50-70% working conditions. Furthermore, the estimator can effectively handle process noise with a 10% feed offset. The proposed platform requires only a few installed sensors yet can accurately estimate unknown parameters. The proposed approach offers a robust and practical soft sensor solution for gravitational oil-water separators.

Keywords: semi-empirical model, multi-model hypothesis testing, Kalman filter, gravitational oil-water separation, state estimation, measurements

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Implementation of Bidirectional Encoder Representations from Transformers in a Content-based Music Recommendation System for Digital Music Platform Users

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Digital music platform users can access millions of songs from various genres and artists through music streaming services. However, with so many music platforms available, users often need help finding songs that suit their preferences. This study presents a music recommendation system that utilizes lyrical analysis to provide users with relevant song suggestions based on selected lyrics. The system employs a two-pronged approach: the Term Frequency-Inverse Document Frequency (TF-IDF) method for initial feature extraction and the IndoBERT model for advanced contextual representation of song lyrics. Adataset of 8,944 Indonesian language songs was compiled using scraping techniques from various sources. The recommendation process is driven by cosine similarity calculations between the lyrics of the selected songs and the entire dataset, enabling the identification of songs with similar themes and messages. Model evaluation through a five-fold Multi-Class Cross-Validation (MCCV) approach yielded promising results, indicating high precision, recall, and F1 scores. The study results show that the system built can provide recommendations with good precision performance with Precision@k values varying between 0.7965 to 0.8371, Recall@k values ranging from 0.8017 to 0.8204, and F1-score@k values varying between 0.8083 up to 0.8190. Overall, the model shows strength in providing accurate recommendations and good performance stability

Keywords: Content-based Music Recommendation, Cosine Similarity, BERT, Monte Carlo Cross-Validation

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Performance Comparison of Particle Filter, Optical Flow, and CSRT in Unsupervised Visual Tracking for Mobile Robots

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This study addresses the challenges of selecting a suitable visual tracking method for real-time mobile robot applications, particularly in scenarios where the target is moving on the ground. The primary research problem addressed is the need for a flexible, computationally efficient tracking method that does not rely on pre-existing labeled datasets, as is often required by deep learning approaches. Unsupervised methods can overcome this problem by utilizing object motion information in each image frame without prior training. With many unsupervised tracking methods available, choosing an appropriate algorithm that can perform efficiently under dynamic conditions becomes a critical problem. The study compares the performance of three unsupervised visual tracking methods: particle filter, optical flow, and channel and spatial reliability tracker (CSRT) under various tracking

conditions. The dataset used includes challenges such as moving target variations, changes in object scale, viewpoint changes, suboptimal lighting, image blurring, partial occlusions, and abrupt movements. Evaluation criteria include tracking accuracy, resistance to occlusion, and computational efficiency. The particle filter with ORB and a constant velocity model achieves a root mean square error (RMSE) of 36.47 pixels at 13 frames per second (fps). Optical flow performs best with an RMSE of 10.79 pixels at 30 fps, while CSRT shows an RMSE of 252.35 pixels at 4 fps. These findings highlight the effectiveness of optical flow for real-time applications, making it a promising solution for mobile robot visual tracking in challenging situations.

Keywords: Unsupervised visual tracking, mobile robots, particle filter, optical flow, CSRT, real-time tracking.

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A Robust SMO-PLL Estimation Algorithm for Enhancing Rotor Position Accuracy and Reducing Chattering Issues in Sensorless FOC of SPMSM

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Recent advancements in sensorless Field-oriented Control (FOC) of Surface Permanent Magnet Synchronous Motors (SPMSMs) have improved system reliability and cost-effectiveness. However, limitations such as speed chattering and inaccurate rotor position estimation remain problematic for Electric Vehicle (EV) applications. This study developed a sliding mode observer-phase locked loop (SMO-PLL) algorithm applied to sensorless FOC in SPMSMs. The SMO predicts the back EMF of the SPMSM, which the PLL then uses for precise rotor position and speed estimation. Simulations conducted in MATLAB Simulink demonstrate that the SMO-PLL significantly reduces chattering and achieves a rotor position estimation error of only 1 rad/min. While the quantitative integral error criteria for SMO-PLL (IAE: 0.0868, ITAE: 0.3069, ISE: 0.0229, ITSE: 0.0834) are slightly higher than those of Field Observer (FO) and Extended Electromagnetic Field Observer (EEMFO), speed control analysis confirms that SMO-PLL delivers a rapid steady-state response with minimal overshoot and oscillation. These findings are crucial for applications where speed stability is essential for passenger comfort and safety, highlighting the SMO-PLL's potential as a robust sensorless control solution for future EVs.

Keywords: Sliding Mode Observer, SPMSM, Phase Locked Loop, Field-oriented Control, Rotor Position Estimation, Motor Speed Estimation.

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IoT-Based Smart Plug with Real-Time Energy Measurement Optimization and Adaptive Current Cutoff

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The use of electrical energy as a primary power source is increasing, with the residential sector being one of the largest consumers. Electrical energy expenditure often occurs accidentally, potentially leading to energy waste. This research developsan IoT-based electricity usage monitoring system to minimize electrical energy waste and help users improve efficiency and protection against voltage spikes using the R&D approach with a waterfall model. There are 3 layers of IoT architecture using the PZEM-004T sensor as a measuring device for electrical parameters and ESP8266 as a communication module where the results of the sensor readings will be displayed in real-time on the LCD and Blynk with a time difference of 1.6 seconds, in addition to the cost indicator, and the current flowing conditions are also displayed. Sensor readings are valid with values < ±0.5% for current and voltage and < ± 1% for power readings. System monitoring tests were carried out on 10 electronic devices, and the results of the estimated electricity costs from the use of electrical energy of these electronic devices were obtained. The system is also equipped with a protection feature displayed with a warning indicator, where if the current exceeds 3.1A, the power will automatically be cut off within 15 seconds. This system provides a solution to the efficiency of electrical energy expenditure and provides more protection.

Keywords: Smart plug, monitoring system, Internet of Things, electrical energy, warning indicators.

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Cardiac Imaging with Electrical Impedance Tomography (EIT) using Multilayer Perceptron Network

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This research explores the enhancement of Electrical Impedance Tomography (EIT) for cardiac imaging using Multilayer Perceptron (MLP) networks, focusing on supervised and semi-supervised learning approaches. Using synthetic thoracic datasets simulating dynamic cardiac and respiratory conditions, the study demonstrates that supervised learning achieve slower mean squared error (MSE) values (minimum 4.76) and more stable predictions compared to semi-supervised learning (minimum MSE 5.08). However, semi-supervised learning excels in edge accuracy and noise reduction, particularly in regions with sharp conductivity gradients, making it a viable method for scenarios where labeled data is limited. Dropout regularization at 0.3 provided an optimal balance, enhancing model generalization and robustness. While supervised learning outperformed semi-supervised methods in overall accuracy, the latter showed potential for cost-effective and scalable applications in EIT-based cardiac imaging. These findings suggest that integrating advanced machine learning with EIT can improve diagnostic accuracy and enable efficient use of sparse labeled data, paving the way for future optimizations and clinical applications.

Keywords: Electrical Impedance Tomography, Multilayer Perceptron, Semi-Supervised Learning, Cardiac Imaging, Machine Learning.

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Implementation of LIDAR for Navigation, Geometric Shape Mapping, and Center of Mass

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This study examines the ability of Light Detection and Ranging (LIDAR) to enhance autonomous vehicle navigation through laser-based distance measurement. LIDAR technology, which has become increasingly vital in robotics and autonomous vehicles, enables the identification and mapping of objects in real time with high accuracy. The integration of LIDAR with the Robot Operating System (ROS) further enhances the system's capabilities by providing a robust framework for sensor data processing and control algorithms in an autonomous system. In this research, LIDAR is applied to indoor navigation, focusing on mapping objects in the shapes of rectangles, triangles, and circles. The data obtained from LIDAR are used by a condition-based (if-else) navigation system on a mobile robot to determine the dimensions of objects and the location of their center points. The results show that LIDAR can provide effective feedback in navigation systems, with object mapping consistent with preconfigured maps. The recorded mapping error rate is 1.93%, demonstrating that this technology is reliable for autonomous navigation applications.

Keywords: LIDAR; Robot Operating System (ROS); Navigation; Center of mass.

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