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Modulation Recognition Algorithm of Multipath Channel Signal for Orthogonal Frequency Division Multiplexing

PROJ24003

This research proposes a new deep learning-based method for signal modulation recognition in orthogonal frequency division multiplexing (OFDM) systems, specifically addressing the challenges of multipath channel effects. The approach first uses a subspace imperceptive channel estimation algorithm and a minimum mean square error (MMSE) equalization algorithm to preprocess the received signal and reduce distortion. An improved convolutional neural network (CNN) then classifies the modulation of the processed signal. The method was tested on six modulation modes and achieved an average recognition accuracy of 0.931, with particularly high performance at a 10SNR. With a rapid testing time of 1.61×10^{-4} s, this algorithm offers superior practicality and accuracy compared to existing methods. The results provide a promising solution to enhance the overall performance, reduce error rates, and improve the anti-interference ability of OFDM communication systems.

Engaging Students in Audiovisual Coding Through Interactive MATLAB GUIs

PROJ24005

Traditional educational methods often fail to effectively teach complex audiovisual signal coding. To address this, this study introduces three novel graphical user interface (GUI) applications developed using MATLAB to enhance student engagement and foundational knowledge in audio, image, and video coding. Integrated into a university computer vision course, these interactive tools provide hands-on experience, bridging the gap between theoretical concepts and practical application. The effectiveness of the tools was rigorously evaluated using a comprehensive methodology, including pre- and post-tests, the System Usability Scale, and the Evaluation Tool for Learning Quality. The results demonstrated a significant improvement in student knowledge, along with overwhelmingly positive feedback on the tools' usability and educational value. These findings suggest that interactive, hands-on learning tools can be a valuable supplement to traditional lectures, boosting both knowledge retention and student engagement in higher education.

Intrusion Detection for Wireless Sensor Network Using Particle Swarm Optimization Based Explainable Ensemble Machine Learning Approach

PROJ24006

This paper proposes a novel Intrusion Detection System (IDS) to secure Wireless Sensor Networks (WSNs), addressing challenges like imbalanced datasets and complex attacks. The system employs a hybrid approach, using Particle Swarm Optimization (PSO) to enhance an ensemble machine learning model that combines Random Forest, Decision Tree, and K-Nearest Neighbors. To handle data imbalance, the model incorporates SMOTE-Tomek techniques. Furthermore, it integrates Explainable AI (XAI) methods such as LIME and SHAP to ensure the results are interpretable. Extensive testing on the WSN-DS dataset demonstrates the system's efficacy, achieving a high accuracy of 99.73%, along with precision, recall, and F1 scores of 99.72%. This performance surpasses existing methods, providing a robust, scalable, and transparent solution for securing WSNs in various applications.

Enhanced Visible Light Communication for Real-Time Audio

PROJ24007

This paper introduces a novel visible light communication (VLC) transceiver design to overcome the challenges of real-time audio streaming, such as interference and synchronization issues. The proposed system incorporates advanced interference-resilient protocols, dynamic frame structuring, and robust error correction algorithms. This design achieves a high signal-to-noise ratio (SNR) of 45 dB and a significantly low bit error rate (BER) of 1×10^{-6}. Performance metrics also show a 50% reduction in total latency and a 66.7% reduction in synchronization errors. The audio quality is rated highly with a mean opinion score (MOS) of 4.8 and an objective difference grade (ODG) of -0.5. Comparative analysis confirms that this system outperforms traditional Wi-Fi and other state-of-the-art VLC designs, establishing it as a reliable solution for high-fidelity audio applications and a foundation for the broader adoption of VLC technology.

Evaluation of Selected Modulation Technique in Underwater Multipath channel

PROJ24008

This paper investigates the suitability of radio communication techniques for challenging Underwater Acoustic (UWA) channels, particularly in shallow waters with strong multipath effects. The study compares two radio modulation methods, BPSK and Chirp Spread Spectrum (CSS) from LoRa systems, with the Multiple Binary Frequency Shift Keying (MBFSK) modulation, which is specifically designed for underwater wireless communication. The researchers used both simulations and real-world measurements from a towing tank to evaluate the performance of these techniques. The key finding was that the simulation results and the real-world measurements differed significantly, leading to the conclusion that existing simulation models may not accurately capture the complexities of the UWA channel. This highlights a crucial need for more precise modeling to enable the effective transfer of radio communication solutions to underwater applications.

Performance Analysis of UAV-Based FSO Communication System for Traffic Monitoring and Management in Smart Cities

PROJ24013

This paper introduces a UAV-based Free-Space Optical (FSO) communication system with an Alamouti scheme for traffic monitoring and management in smart cities. The system utilizes an Unmanned Aerial Vehicle (UAV) as a relay to enhance coverage and operates as a dual-hop FSO communication system. The Alamouti scheme is employed to mitigate the effects of atmospheric turbulence and improve overall system performance. The research investigates the system's performance by considering key factors such as atmospheric loss, pointing errors, turbulence, and angle-of-arrival fluctuation caused by the UAV's hovering state. The symbol error rate (SER) is theoretically determined using the moment generating function (MGF) technique. This theoretical equation is then simulated in MATLAB and validated with a Monte-Carlo simulation, confirming the system’s potential for efficient and reliable urban traffic management.

Exploring the Effectiveness of Machine Learning and Deep Learning Techniques for EEG Signal Classification in Neurological Disorders

PROJ24016

This study explores the use of machine learning (ML) and deep learning (DL) to detect neurological disorders like Epilepsy, Autism Spectrum Disorder (ASD), and Alzheimer's disease from Electroencephalography (EEG) signals. The research outlines a detailed workflow beginning with data acquisition and preprocessing using FIR filters and ICA to eliminate noise. Following this, key features such as Bandpower and Shannon entropy are extracted to enhance classification accuracy. The study's findings demonstrate impressive results, with a Random Forest model achieving 99.85% accuracy for autism classification and a Support Vector Machine (SVM) model reaching 100% accuracy for distinguishing dementia from healthy subjects. Additionally, deep learning models like CNN and ChronoNet showed high accuracy ranging from 92.5% to 100%. In conclusion, this research confirms the effectiveness of ML and DL techniques in EEG signal processing, offering significant contributions to neurological disease diagnosis and brain-computer interface applications.

Evaluation of Uplink Video Streaming QoE in 4G and 5G Cellular Networks Using Real-World Measurements

PROJ24024

This study presents a comprehensive methodology for evaluating the Quality of Experience (QoE) for uplink video streaming in commercial 4G and 5G networks, a crucial task given the rise of live content creation. The research addresses the challenge that these networks are primarily optimized for downlink traffic. The methodology involves extensive data collection from network elements and streaming servers, focusing on factors like signal strength, network congestion, and Physical Resource Block (PRB) allocation. To assess video quality, the study uses full-reference metrics such as VMAF, SSIM, and PSNR. A robust dataset, including video files, IP packet data, and Radio Access Network (RAN) measurements, enables powerful regression analysis and machine learning for QoE prediction. The results provide valuable insights into the relationship between network conditions and video quality, offering practical solutions to optimize uplink streaming performance in current and future cellular networks.

EEG Based Detection of Induced Relaxation

PROJ24030

This study utilizes electroencephalography (EEG) to detect induced relaxation in real time, employing the Multivariate Empirical Mode Decomposition with Dynamic Phase-Synchronized Hilbert-Huang Transform (MEMD-DPS-HHT) algorithm. Participants were exposed to blended essential oils, and their EEG data were preprocessed with Independent Component Analysis (ICA) and bandpass filtering. The data were then decomposed into intrinsic mode functions (IMFs) to analyze dynamic brain wave patterns. While the analysis demonstrated the MEMD-DPS-HHT's capability to process cross-channel, multi-dimensional data, the results showed no statistically significant difference in the Theta and Alpha (TA) bands pre- and post-stimulation ($p \geq 0.05$). The low average relaxation index suggests that the blended essential oils had a minimal or inconsistent effect on relaxation across the participants. This highlights that the impact of such stimuli may be highly individual.

MLAR-Net: A Multilevel Attention-Based ResNet Module for the Automated Recognition of Emotions Using Single-Channel EEG Signals

PROJ24043

This paper introduces MLAR-Net, a novel multilevel attention module for accurate emotion recognition from a single-channel EEG signal. A key challenge in this field is the small quantity of available data, which the researchers address by converting EEG signals into spectrograms using multiple parameters to generate a large set of images. The processed data is then fed into MLAR-Net, which integrates a multilevel attention module with a ResNet18 architecture. The study found that channel T7 (channel number 24) is the most effective for emotion classification, achieving a remarkable average accuracy of 98.06% and a maximum accuracy of 99.51% using fine K-Nearest Neighbors. Conducted on the publicly available SEED dataset (positive, negative, and neutral emotions), this approach demonstrates a 4-5% improvement over state-of-the-art methods using the same channel, paving the way for real-time systems with a minimal number of channels.

Magneto Inductive (MI) Channel Variables Prediction Through Machine Learning Linear Regression Method, for Underwater and Underground WSNs

PROJ24045

This study explores Magneto Inductive (MI) communication as a robust and secure solution for Wireless Sensor Networks (WSNs), particularly in challenging underwater and underground environments. The research leverages the inherent directionality of magnetic flux from MI tri-directional (MI-TD) coils to enhance communication link resilience and control information security. The study systematically examines how key factors like the frequency of the excitation current, the number of coil turns, the coil radius, and the communication distance affect the MI channel's response. A linear regression machine learning (ML) model was developed to predict the values of these variables, which in turn helps forecast the channel's response in terms of Path loss/Bit Error Rate (BER). This predictive model achieved an impressive estimation accuracy of 92%, providing a powerful tool for analyzing and optimizing MI communication links.

Pattern-Based Assessment of the Association of Fetal Heart Variability With Fetal Development and Maternal Heart Rate Variability

PROJ24046

(fHRV) alone due to maternal and fetal factors. The new parameter, called dmf, is calculated as the difference between maternal and fetal HRV derived from non-invasive ECG recordings. By using dmf to categorize data from 158 subjects into three patterns, the research investigated the association of fHRV with gestational age (GA) and maternal HRV (mHRV). The results revealed discrepancies in the link between fHRV and GA, suggesting that fHRV is not a constant indicator of fetal autonomic nervous system (fANS) development. These discrepancies are attributed to maternal influences, as mHRV showed a pattern-specific correlation with fHRV. The findings provide a new, more nuanced approach to assessing fHRV and fetal development relative to maternal conditions.

FAViTNet: An Effective Deep Learning Framework for Non-Invasive Fetal Arrhythmia Diagnosis

PROJ24048

This study presents a three-stage framework for detecting fetal arrhythmia, a critical task for evaluating fetal cardiac health. The process begins by extracting the fetal electrocardiogram (fECG) from the abdominal ECG using a functional link neural network adaptive filter, followed by denoising with a robust generative adversarial network (GAN). The core of the system is the final stage, which employs a deep convolutional architecture called FAViTNet. This architecture analyzes high-resolution spectral images generated by the Stockwell transform. It uses ghost bottleneck blocks to create feature maps that are converted into 1D token embeddings, with channel-wise calibration to enhance attention. A transformer encoder block then captures long-term dependencies to effectively classify fetal arrhythmia. The proposed algorithm demonstrates high performance, achieving an accuracy of 96.85%, sensitivity of 96.69%, and specificity of 96.98%.

Electric Vehicles CAN Bus Cyber AttacksDetection Using Adaptive Neuro Fuzzy Inference System

PROJ24050

The Electric Vehicle (EV) industry has recently experienced notable technological progress in the field of Controller Area Network (CAN) protocol. The use of CAN bus protocol in EVs is exposed to intrinsic cybersecurity risks and consequently causing EV damages as a result of lack of authentication, authorization, and accounting mechanisms. This paper examines the vulnerabilities within the EVs' CAN bus protocol and explores potential strategies for mitigating cyber threats (i.e. Denial of Service (DOS) and impersonation attacks). In particular, the paper proposes Adaptive Neuro Fuzzy Inference System (ANFIS) based detection techniques superimposed with Subtractive Clustering (SC) and Fuzzy C-Means clustering (FCM). Results demonstrate that the proposed ANFIS-SC and ANFIS-FCM detection model testing accuracy is 99.6%, TPR and TNR values are above 99.8%. In addition to the low FPR and FNR values are less than 0.2% of the proposed ANFIS-SC and ANFIS-FCM detection techniques. The overall F1 score is above 98.8%.

Coverage Probability of RIS-Assisted Wireless Communication Systems With Random UserDeployment Over Nakagami-m FadingChannel

PROJ24114

In beyond 5G (B5G) networks, millimeter-wave (mmWave) communications suffer from high vulnerability to blockages due to increased directivity and attenuation. Reconfigurable Intelligent Surfaces (RIS) have emerged as a promising solution to mitigate blockage effects and enhance system performance. This paper presents a novel analytical framework for RIS-aided wireless systems with randomly deployed users following the Random Waypoint (RWP) mobility model over Nakagami-m fading channels. We derive new closed-form expressions for end-to-end signal-to-noise ratio (SNR), coverage probability, and ergodic capacity, accounting for both direct and RIS-assisted indirect links. The impact of key parameters—blockage density (λb), number of RIS reflecting elements (N), fading severity (mR), and path loss exponent (α)—on system performance is thoroughly analyzed. Results show that increasing blockage density and path loss degrades coverage, while increasing RIS elements and fading parameter significantly improves coverage by enhancing signal strength and mitigating fading. For instance, coverage probability at −10 dB improves from 0.3 to 0.8 when RIS elements increase from 15 to 40, demonstrating RIS's effectiveness in B5G scenarios.

Early Diagnosis of Alzheimer's Disease Using Adaptive Neuro K-Means Clustering Technique

PROJ24025

This study presents a novel framework for early Alzheimer's Disease (AD) diagnosis using T1-weighted MRI by combining Adaptive Moving Self-Organizing Map (AMSOM) with K-means clustering and Principal Component Analysis (PCA) for effective tissue segmentation and feature selection. AMSOM enhances segmentation accuracy by dynamically updating neuron weights during unsupervised training. Various classifiers were employed to evaluate performance based on sensitivity, accuracy, precision, and similarity metrics. Compared to established methods like Fuzzy C-means (FCM) and hybrid SOM-K-means, the proposed approach significantly improves tissue segmentation and classification, achieving a mean accuracy of 99.8%, reducing Mean Squared Error (MSE) from 2.3 to 0.44, and enhancing Discriminative Overlap Index (DOI) and Tissue Clarity (TC) to 0.435 and 0.282, respectively. Implemented in MATLAB, this method offers a robust, efficient, and reliable framework for early AD detection, addressing the diagnostic challenges of Mild Cognitive Impairment progression and surpassing existing techniques in precision and effectiveness.

Automatic Segmentation of Asphalt Cracks on Highways After Large-Scale and Severe Earthquakes Using Deep Learning-Based Approaches

PROJ24034

This study presents a deep learning-based automated system for detecting and segmenting earthquake-induced asphalt cracks, enabling rapid and accurate post-disaster road assessments. Traditional manual inspections are time-consuming and error-prone, whereas our approach utilizes advanced segmentation models for pixel-level classification of crack types. A key challenge was creating a high-accuracy, expert-labeled dataset following two major earthquakes in Turkey (Mw 7.7 and 7.6) in 2023, capturing real post-earthquake highway damage. We evaluated popular deep learning segmentation models—SegNet, Attention SegNet, U-Net, FCN (8s), and DeepLab—on this unique dataset. SegNet outperformed others, achieving an average accuracy of 86.72%, precision of 92.99%, and sensitivity of 78.45%. This work offers an unbiased performance comparison and establishes a reliable framework for real-time infrastructure monitoring. The novel dataset and demonstrated model effectiveness support future strategies to enhance transportation network resilience and safety in earthquake-prone regions.

Transfer Learning for Ultrasound-Based Kidney Stone (Urolithiasis) Detection with Augmented Regularization and Saliency Maps

PROJ24039

Urolithiasis, or kidney stones (KS), affects millions globally and requires rapid diagnosis to prevent complications. Ultrasound imaging is preferred for diagnosis due to its safety and lack of radiation risk. This study develops a deep learning-based system to detect kidney stones from ultrasound images using a dataset of 9,416 images (4,414 normal and 5,002 KS). Images were preprocessed with resizing, rescaling, and center cropping, then split into training, validation, and testing sets. Four pretrained deep learning models—DenseNet201, ResNet50, InceptionV3, and MobileNetV3—were employed. Augmented regularization techniques such as MixUp and CutMix improved model robustness. Hyperparameter tuning was performed for optimal performance. Two training approaches were explored: feature extraction using frozen pretrained layers, and fine-tuning of pretrained models. DenseNet201 achieved the highest accuracy of 99.73%. Model predictions were interpreted using saliency maps to highlight important regions. After 1,000 iterations, the model's 99% confidence interval ranged between 0.993 and 0.999, demonstrating its high reliability for kidney stone detection.

Contrast Limited Adaptive Local Histogram Equalization Method for Poor Contrast Image Enhancement

PROJ24113

Contrast Limited Adaptive Histogram Equalization (CLAHE) is widely used for image enhancement due to its efficiency and simplicity, but it suffers from manual parameter tuning and fixed enhancement weights, often causing artifacts. Existing solutions face challenges such as complexity, sensitivity to parameters, dependence on initial image quality, and high computational cost, with inconsistent performance across diverse image types. This paper introduces Contrast Limited Adaptive Local Histogram Equalization (CLALHE), a novel method that adaptively enhances image contrast locally without requiring user input. CLALHE identifies optimal enhancement parameters through multiple enhancement trials, determines these parameters adaptively, and applies them independently to subimages to emphasize local features. The enhanced subimages are then combined to produce the final output. Evaluations on three datasets (DIARETDB1, Pasadena-Houses 2000, and Faces 1999) demonstrate CLALHE's superior performance, delivering improved contrast, clearer details, and reduced processing time. Quantitative metrics—including peak signal-to-noise ratio, entropy, mean brightness error, structural similarity, and contrast improvement index—confirm CLALHE's effectiveness over existing methods.

EV-Fusion: A Novel Infrared and Low-Light Color Visible Image Fusion Network Integrating Unsupervised Visible Image Enhancement

PROJ23358

Infrared and visible image fusion combines complementary information from both modalities, preserving critical target details and rich textures. However, existing methods often struggle in low-light conditions, as visible images suffer from poor brightness and inadequate color enhancement, leading to unsatisfactory fusion results. To overcome these limitations, we propose EV-fusion, a novel approach that enhances both color and detail features in visible images to improve the visual quality of fused outputs. Our method includes an unsupervised image enhancement module that restores texture, structure, and color using multiple non-reference loss functions. Subsequently, an intensity image fusion module integrates the enhanced visible image with the infrared image. Additionally, to emphasize infrared salient objects, we introduce an infrared bilateral-guided salience map embedded in the fusion loss functions. Extensive experiments demonstrate that EV-fusion outperforms state-of-the-art infrared-visible fusion methods, delivering superior visual perception and robustness, especially under challenging low-light conditions.

Trajectory Planning of Autonomous Vehicles to Ensure Target QoS Requirements in 6G Mobile Networks

PROJ23359

The rollout of 6G networks promises ultra-fast speeds, low latency, and extensive connectivity, enabling advanced Intelligent Transportation Systems (ITS) for autonomous vehicles (AVs). This paper investigates trajectory optimization for AVs in urban environments using millimeter wave (mmWave) communication, where coverage is often fragmented. We model the Manhattan grid as a graph with intersections as nodes and edges weighted by the minimum Spectral Efficiency (SE) of connecting streets. Using a Max-Min scheme, the AV's path is selected to maximize the minimum SE encountered, ensuring consistent Quality-of-Service (QoS) throughout the journey. Simulation results demonstrate that the Max-Min trajectory optimization significantly enhances network performance, yielding 40%-60% gains in the 10th percentile SE and 20%-30% improvements in the 50th percentile SE compared to non-optimized routes. These findings highlight the potential of integrating 6G network awareness into AV route planning to deliver reliable, high-bandwidth services and support autonomous driving decisions in complex urban scenarios.

SECURING 6G WIRELESS TRANSMISSION THROUGH QUANTUM KEY DISTRIBUTION INTEGRATED WITH VISIBLE LIGHT COMMUNICATION

PROJ23360

With 6G communication systems on the horizon, securing networks against quantum computing threats is crucial. Classical cryptographic algorithms face increasing vulnerability to quantum attacks, positioning Quantum Key Distribution (QKD) as a promising solution for unconditional security grounded in quantum mechanics. This work reviews the integration of QKD into 6G design, assessing its potential implementations in both fiber and wireless environments. We compare key performance indicators—including secret key generation rates, quantum bit error rates (QBER), noise resilience, and user mobility—in simulated 6G scenarios. Additionally, we explore hybrid security models combining classical post-quantum cryptography (PQC) with QKD to establish multilayered defenses. The role of AI/ML in enhancing QKD performance through smart error correction, adaptive key management, anomaly detection, and dynamic routing is also analyzed. Despite advances, challenges remain in scalability, standardization, interoperability, and deployment. We conclude by outlining future research directions focused on AI-empowered QKD, global protocol standardization, and real-world testbeds to enable quantum-safe 6G networks.

Design of a Cross-Layer Anti-Jamming Routing Protocol for FANETS Based on Spatial Filtering

PROJ23361

Flying Ad Hoc Networks (FANETs) play a critical role in future integrated air-space systems, demanding routing protocols that adapt to dynamic network changes and challenging electromagnetic environments. This paper presents a novel approach to routing in FANETs by incorporating link quality factors that reflect nodes' spatial disturbance resistance capabilities. We propose a cross-layer anti-jamming multi-hop routing protocol designed to enhance reliability and resilience in highly contested environments. By evaluating link quality with respect to each node's ability to resist spatial disturbances, the protocol identifies the most reliable routes, improving overall network performance. Simulation results demonstrate that when nodes possess spatial disturbance resistance, routing decisions based on link quality maintain high average throughput and low packet loss rates even under interference. This approach offers a promising solution to improve communication

Integrating Data Privacy and Energy Management in Smart Cities With Partial Sustainable IoT Networks

PROJ23362

This article addresses the challenge of managing energy resources in partially sustainable IoT networks within smart cities, where both sustainable nodes with energy harvesting and traditional non-sustainable nodes coexist. Efficient sharing of Energy Information (EI), such as battery state-of-charge, is critical but exposes nodes to energy-based attacks targeting vulnerable devices. To mitigate this, we propose the Dual Energy PROfile for interNet-of-thiNgs with Enhanced Security (DEPRONN-ES), a framework that supports mixed-node networks while applying differential privacy to secure EI sharing. Our evaluation, using IoT device emulation and real indoor light intensity data from Columbia University as a harvesting source, demonstrates that DEPRONN-ES reduces attack success rates by 87% and improves resource consumption resilience in attacked nodes. Additionally, the framework effectively manages conflicting energy consumption profiles, enabling sustainable and traditional nodes to operate efficiently together. DEPRONN-ES offers a robust, privacy-preserving solution to advance green IoT deployments in smart city environments.

Deep Learning-Based Data-Assisted Channel Estimation and Detection

PROJ23363

We propose a novel deep learning-based framework to enhance channel estimation and data detection in MIMO-OFDM systems. At its core is a Denoising Block composed of three specialized deep neural networks designed to extract clean signal embeddings from noisy received signals. Complementing this, we introduce a Correctness Classifier that identifies accurately detected data symbols by analyzing the denoised signals. These reliably classified symbols are then reused as additional pilots to refine channel estimation, improving accuracy. Furthermore, the Denoising Block facilitates direct data detection, making the approach suitable for low-latency scenarios. To train the model effectively, we develop a hybrid likelihood objective tailored for detected symbols and derive analytical gradients to optimize this function. Experimental results demonstrate that our data-aided channel estimator significantly reduces the mean-squared error (MSE) of channel estimation compared to traditional techniques, thereby substantially enhancing overall data detection performance. This integrated approach offers a robust solution for reliable and efficient MIMO-OFDM communication systems.

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99447 93398
info@elysiumpro.in
elysiumpro.in

229, First Floor, A Block,
Elysium Campus,
Church Rd, Anna Nagar,
Madurai, Tamil Nadu - 625020.