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Smart Mobility and Logistics Projects

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2024 – 2025

Cargo-Drone

> High endurance 10-12 h
> Speed 150 km/h
> Hybrid VTOL

High Value Air Logistics

> *Endurance 1h-10h*
>
> *Short Takeoff and Landing*
>
> *Speed 100km/h to 450 km/h*

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Dual-use Autonomous Marine System

> " Hydrogen powered
> Endurance 2-3h
> Surface and Gator modes

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HYDROGEN POWERED AUTONOMOUS MARINE SYSTEMS FOR A SUSTAINABLE FUTURE

Introduction

Hydrogen fuel cells are a game-changing technology for the development of autonomous marine systems. Offering high energy density, extended operational periods, and zero-emission performance, they present a viable solution for sustainable maritime innovation. This poster investigates the potential of hydrogen-powered autonomous systems and their applications in areas such as wildlife monitoring, tourism, and the oil and gas sector.

Objectives

- Achieve 50% automation of logistics for shipments in the Kingdom by 2040.
- Develop intelligent, autonomous systems for automated last-mile delivery, reducing transportation costs by 50% by 2030.
- Contribute to the Kingdom's strategic blue economy by enhancing marine automation for sustainable practices.

Key Innovations

Hydrogen Fuel Cells in Marine Systems:

- Higher energy density compared to conventional batteries.
- Extended operational capabilities, allowing unmanned marine vehicles to function over longer durations.
- Environmentally friendly, with water as the only byproduct, supporting zero-emission objectives.
- Low noise emission, minimizing disturbance in sensitive marine environments.

Modularity and Scalability

- Hydrogen fuel cells can be customized to fit a variety of marine system sizes and power requirements.
- Flexible applications, suitable for everything from small autonomous drones to larger unmanned surface vehicles (USVs).
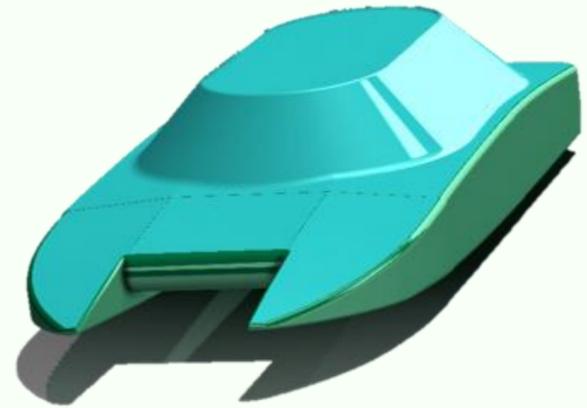
Applications

Wildlife Monitoring:

- Autonomous marine systems with hydrogen fuel cells can support non-invasive monitoring of marine ecosystems, contributing to the advancement of SDG 14 (Life Below Water).

Oil and Gas Infrastructure:

- These systems can provide continuous inspection and maintenance of offshore oil and gas infrastructure, offering high-endurance solutions for industry needs.

Tourism and Recreation:

- Hydrogen-powered autonomous systems can support sustainable recreational and water tourism along the Kingdom's extensive coastline, promoting eco-friendly tourism development.

Model 1:
Dual-use marine system designed for commercial applications and maritime automation.

Unmanned surface vehicle (USV) optimized for long-duration maritime missions, capable of operating with minimal environmental impact.

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A JOINT PLANNING MODEL FOR DISTRIBUTED ENERGY RESOURCES AND WATER DESALINATION PLANTS

Abstract

This work presents a planning model for a distribution system to meet a growing electrical demand that includes a water desalination plants (WDP). The objective is to find the optimal sizes and locations for distributed energy resources (DERs) to supply the expected demands while optimizing the long-term profits for the distribution system operator (DSO). The DERs include photovoltaics (PV), wind turbines (WT), thermal generators (TG), and battery energy storage systems (BESS). The proposed model considers the coordination with the water desalination plant operator (WDPO) in the operational aspect to provide energy flexibility to the DSO.

Contributions and Importance of the Study

- Developing a detailed desalination model that more accurately captures the features and characteristics of desalination operations.
- Developing a planning model to determine the optimal sizing and location of DERs such as PV, WT, TG, and BESS.
- Developing a coordination framework between the DSO and WDPO, which includes providing incentives to the WDPO for shifting the RO-WDP load considering its flexibility.
- Ensuring scalability, the proposed model is formulated as a MILP model that involves linearizing non-linear equations.

Structure of the Proposed Model

- The DN is considered to be connected to the bulk power grid. The DSO operates the DN, whereas the grid is operated by an independent system operator (ISO).
- The interaction between them for buying/selling electricity is based on a deregulated electricity market mechanism.
- To develop the optimal bids to be submitted in the day-ahead, DSO should predict the hourly production of RESs, the load of WDP after coordinating with WDPO, and a load of its other consumers.
- The DSO requests the WDPO to shift a portion of its load, and the DSO must provide an incentive to the WDPO.
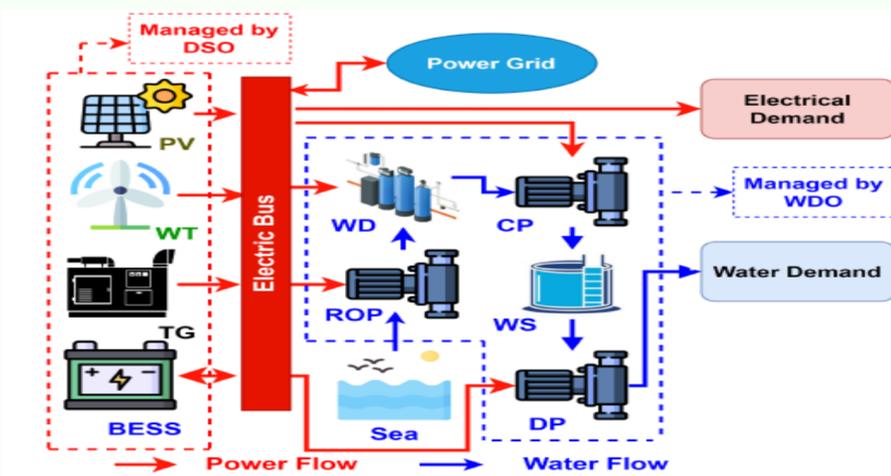

Fig. 1. Proposed model overview

Conclusion and Remarks

- A planning model is proposed for finding the optimal sizes and locations of DERs to feed a growing electrical demand that includes WDPs. The operational aspect considers the coordination with WDPO as an incentive for WDPO to shift a portion of its load. The primary motivation of this work is to study the impact of coordination on the DSO's long-term profitability, capacities, and sizing of DERs, as well as the benefits to the WDPO.
- Two cases have been considered to analyze coordination benefits: case I considers coordination, while case II does not. From the obtained results, the coordination caused the DSO overall profits to increase by 1.79%, while the WDPO overall costs has dropped by 3.19%.
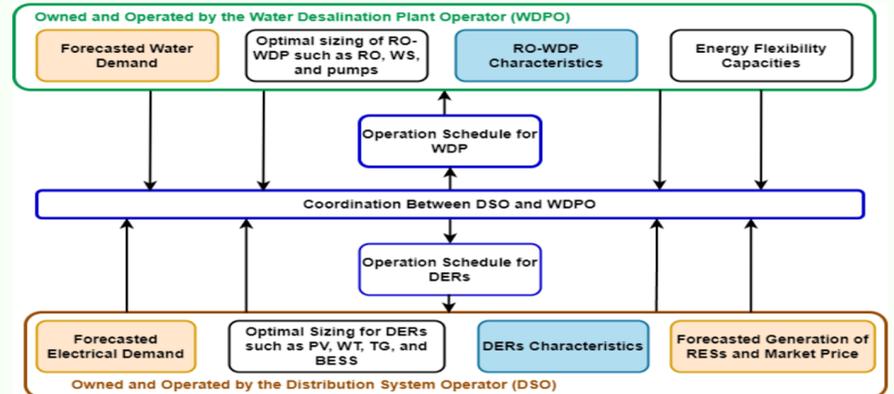

Fig. 2. Coordination framework of DSO and WDPO

Test Results

- The proposed model is assessed in two cases in this section:
- In case I: The coordination with WDPO is considered.
- In case II: The coordination is not considered.

- The following parameters are used:
  - A medium voltage 38 radial DN.
  - 15 years planning horizon.
  - Peak water demand = 150 m3/hr.
  - Electrical peak demand = 6.06 MW.
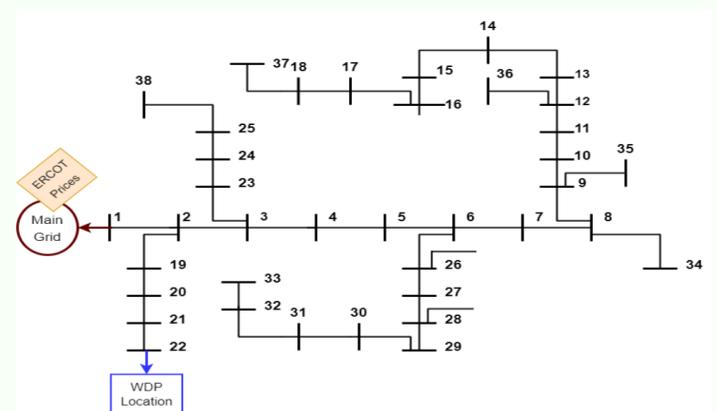 - PV, WT, energy prices, and the electrical load are from ERCOT.

Fig. 3. Test IEEE 38-bus radial DN

Table 1. Overall payoff and optimal sizing in both cases

	With coordination	Without coordination	Coordination gains
Profits to DSO	$8.29M	$8.14M	1.79%
Costs to WDPO	$417 Thousands	$431 Thousands	-3.19%
DERs Capacity Installation			
PV	1.624	1.597	1.68%
WT	4.063	3.537	13.84%
TG	-	0.335	-
BESS	1.526	0.93	48.53%
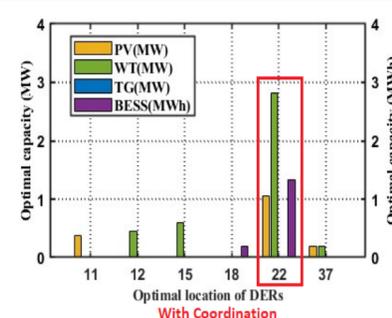
Fig 4. Case I: Optimal sizing and location of DERs
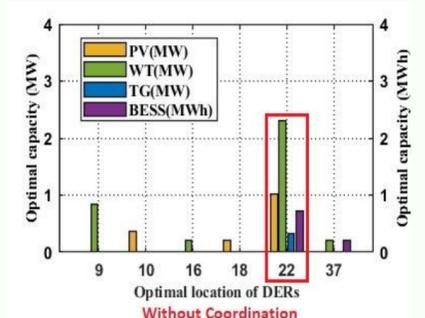
Fig 5. Case II: Optimal sizing and location of DERs

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BALANCING CAPACITY AND CAPABILITY: A NOVEL NETWORK APPROACH FOR EFFICIENT WARRANTY REPAIR COVERAGE

Abstract

This study develops a multi-objective reverse logistics network for managing multi-type warranty returns in closed-loop supply chains using a mixed-integer linear programming model. The model minimizes costs (facility, transport, refurbishment, environmental) and optimizes cycle times and demand fulfilment. A mobile phone case study using the GLPK solver shows improved efficiency, reduced CO2 emissions, and adaptability to demand changes through sensitivity analysis.

Introduction

Closed-loop supply chains (CLSC) and reverse logistics (RL) improve sustainability by reducing waste, optimizing resource utilization, and enhancing customer satisfaction through transparent policies, minimum cycle time, and efficient demand fulfilment [1]. Cost optimization in RL emphasizes efficient resource allocation and low-energy refurbishment. RL faces managerial, financial, strategic, and technical challenges [2, 3]. This study optimizes RL management by examining facility allocation, carbon cap adaptation with inter-facility transport, and return rate impacts on network design. It balances cost and customer satisfaction through:

• Addressing the literature gap on multi-type warranty returns.

• Developing a multi-objective MILP model,

• Sensitivity analysis for robustness.

Methods

• The methodology for designing a Reverse Logistics (RL) network design begins with a literature review to identify models and gaps. After data collection on returns and costs, data is pre-processed by cleaning and normalizing. Mathematical modelling follows, with key notations and assumptions defined, and the problem is formulated as an optimization model. The model is solved using GLPK to find the optimal network configuration. Results are analysed, and sensitivity analysis is performed by adjusting parameters to test model robustness.
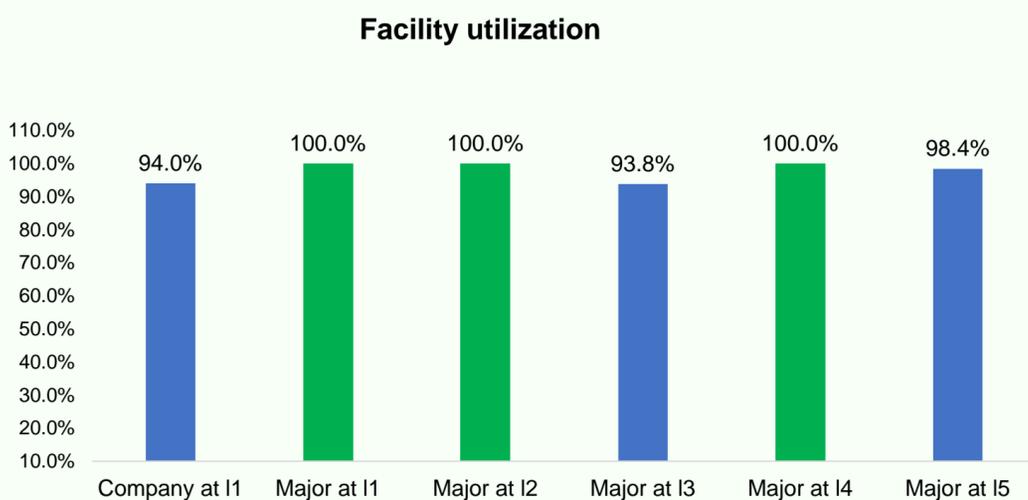
Results and Discussion

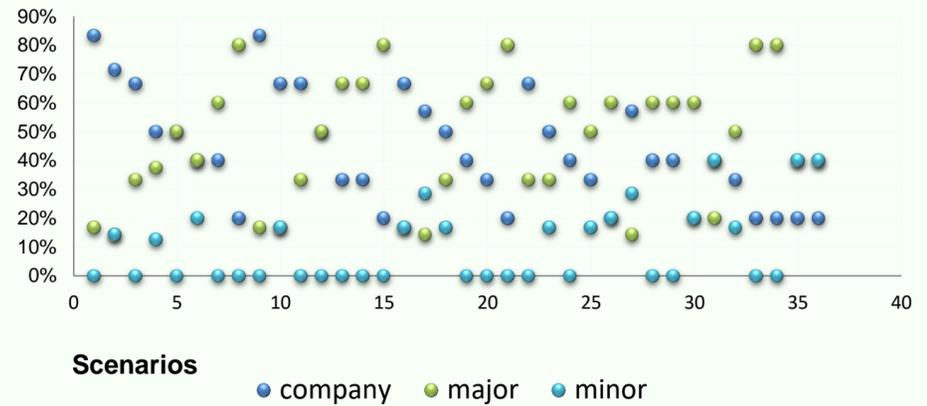**Fig. 1.** Figure of facility utilization

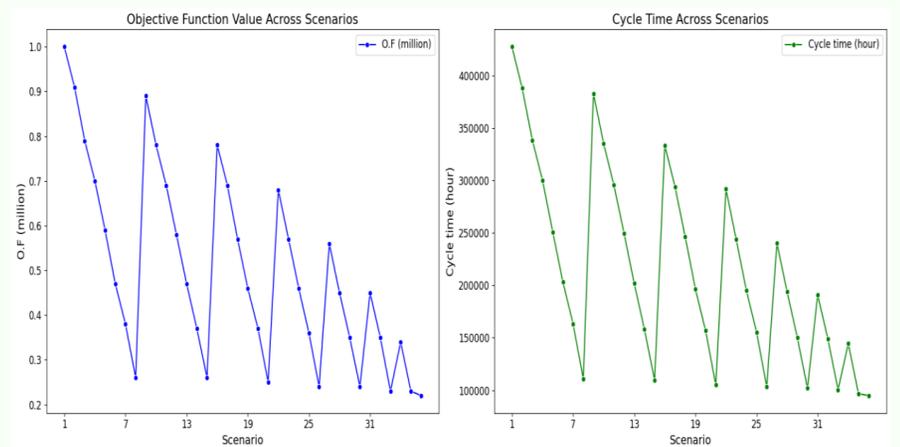**Fig. 2. Figure of scenario analysis : facility allocation**

Fig. 3. Figure of Scenario Analysis: Impact on objective function

Conclusion

• Optimized warranty returns in RL.

• Minimized costs ($0.255M) and cycle time.

• Identified 5 key facilities for A/B returns.

• Facilitates demand variation and transport.

• Prioritizes A/B and C returns efficiently.

• Improves RL network efficiency & sustainability.

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BRAIN ASSESS – INTELLIGENT NEURO-DIAGNOSTIC SYSTEM ENHANCING BRAIN MRI PROCESSING FOR EFFICIENT HEALTHCARE MANAGEMENT IN SMART CITIES

MOTIVATION & BACKGROUND

- Neurological disorders are among the top causes of death worldwide
- Timely and early diagnosis helps in saving and improving lives
- AI-Health care has been the focus of attention by researchers
- AI can assist in a number of ways for diagnosis under different modalities including brain MRI Scans
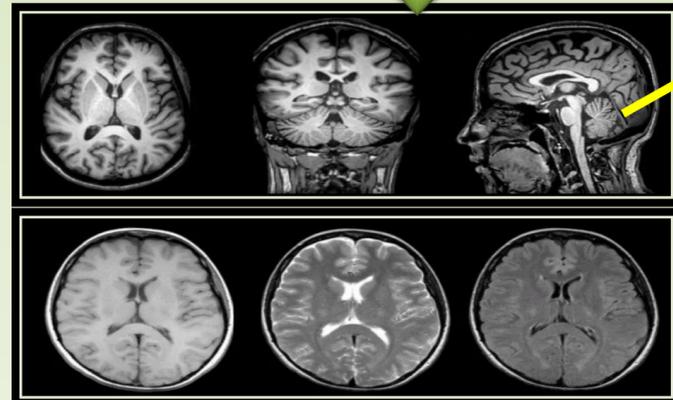- Deep Learning based Intelligent Neuro-Diagnostic Systems can assist the neuro-specialists in timely diagnosis
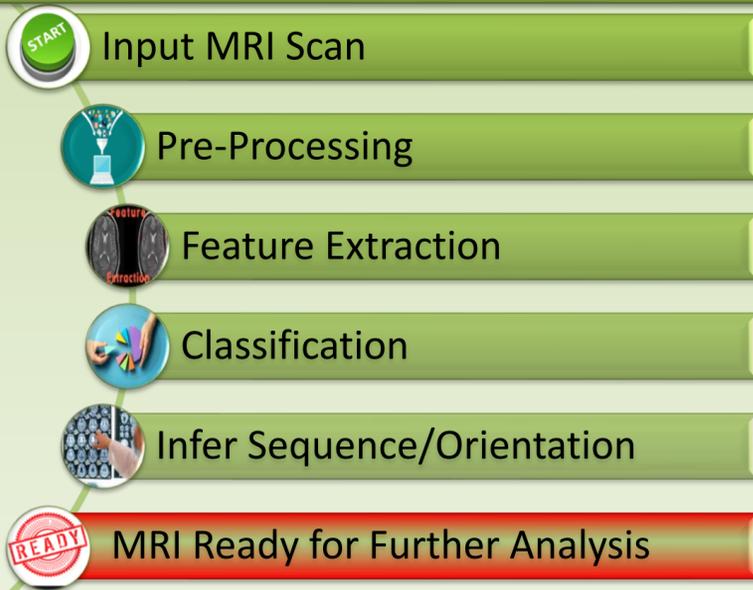
INTRODUCTION

Several types of Brain MRI Planes & Sequences

Sequence
Viewplane
Strength

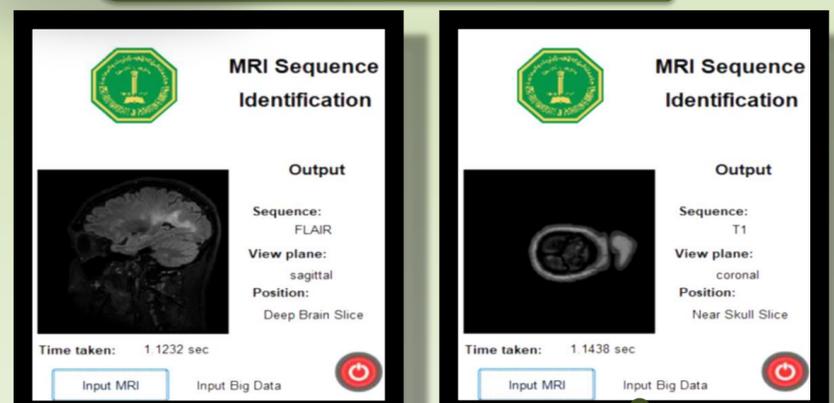Need to be identified before AI-based diagnosis

METHODOLOGY

- START Input MRI Scan
- Pre-Processing
- Feature Extraction
- Classification
- Infer Sequence/Orientation
- READY MRI Ready for Further Analysis

MRI SEQUENCE IDENTIFICATION APP

SUSTAINABLE DEVELOPMENT GOAL
3 GOOD HEALTH AND WELL-BEING

RESULTS

Confusion Matrix for Test Data

99.7% accuracy on Test Data

SAMPLE RESULTS

MRI Sequence Identification

Output
Sequence: FLAIR
View plane: sagittal
Position: Deep Brain Slice
Time taken: 1.1232 sec
Input MRI   Input Big Data

MRI Sequence Identification

Output
Sequence: T1
View plane: coronal
Position: Near Skull Slice
Time taken: 1.1438 sec
Input MRI   Input Big Data

Tested on clinical data

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BRAIN POWERED AUTONOMY IN LOGISTICS OPERATIONS

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DATA-DRIVEN MODELS FOR LOGISTICS OPTIMIZATION

Abstract

The delivery time of goods in the supply chain is a critical enabler for achieving overall supply chain excellence and business success. However, the uncertainty of the delivery times of goods is a significant issue, making it critical for businesses to develop effective logistics and shipping strategies. Accurately forecasting delivery times is needed to maintain smooth logistics operations and, ultimately, reduce overall transportation, shortage, and inventory costs. Consequently, the purpose of this paper is to propose machine learning algorithms for predicting the delivery time and enhancing the responsiveness of the supply chain in the oil and gas industry. The proposed models will help in building a resilient supply chain capable of adapting to unforeseen events and disruptions. In this paper, the factors influencing the delivery time of the goods in the oil and gas supply chain are identified based on reviewing the literature and expert interviews. Different statistical analysis tests are conducted to ensure the quality of data. In addition, the correlation between the input factors and between input and output is investigated. The machine learning models are developed and validated using real data from an important field; the gas and oil industry. The results indicated that the factors that influence the delivery time of the goods in oil and gas include annual order hits, priority, supplier region, product complexity, and transportation method. Moreover, the findings revealed the capability of the proposed models to predict the delivery time with an accuracy higher than 85%. This study provides managers with valuable tools for managing and optimizing their supply chain operations by highlighting the critical factors influencing delivery time and providing a reliable predictive model. In addition, the proposed models are expected to assess the organization in reducing supply chain transportation, inventory, and shortage costs.

Research Objectives

- Identify the factors influencing the delivery time of goods in the oil and gas industry.
- Proposes machine learning algorithms for predicting the delivery time of goods in the oil and gas sector.
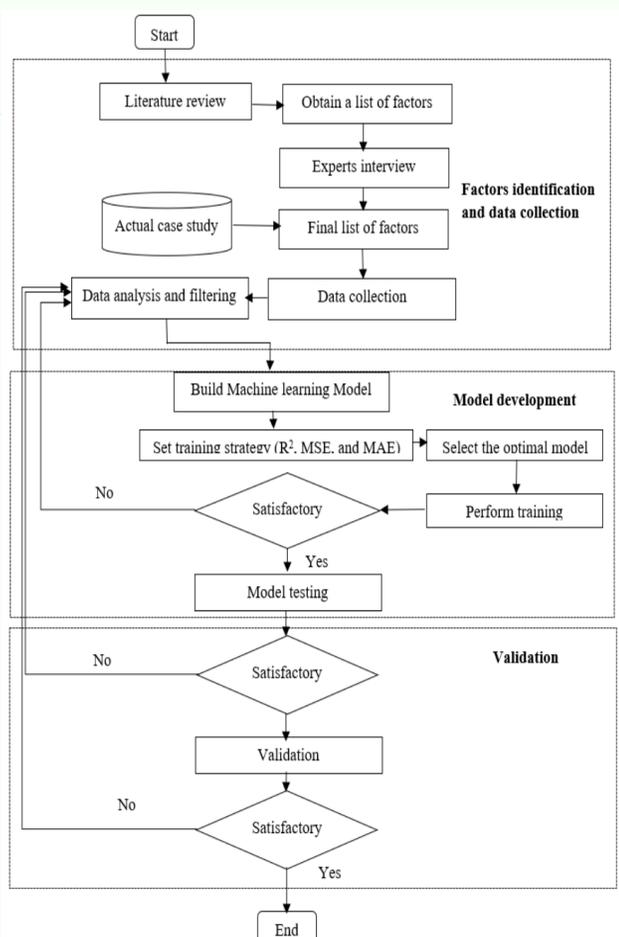- Validate the proposed models using real data from the oil and gas supply chain

Alignment with SDGs

- Accurately forecasting delivery times is necessary to maintain smooth logistics operations and reduce overall transportation, shortage, and inventory costs, directly contributing to SDG 9: Industry, Innovation, and Infrastructure by fostering resilient supply chain systems.

- The proposed models help build a resilient supply chain capable of adapting to unforeseen events and disruptions, addressing SDG 12: Responsible Consumption and Production by reducing waste and optimizing resources

- This research aligns with SDG 8: Decent Work and Economic Growth by promoting sustainable industrialization through technological innovation and efficiency.

Results

Figure 2 shows the Pareto chart for the standardized effects. The chart visually represents the impact of various predictors on lead time, measured in days. The complexity of orders, transportation method, priority have the highest impact of the delivery time of the goods.
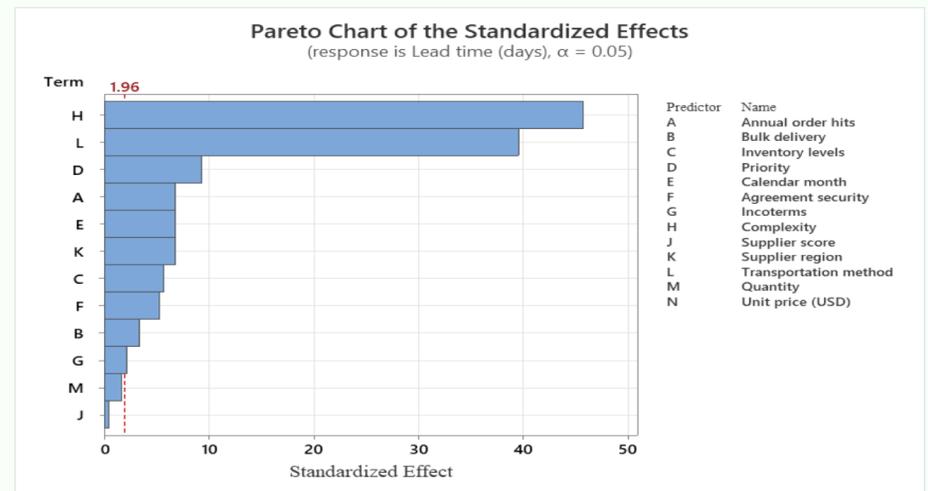

Fig. 2. The standardized effects using Pareto chart

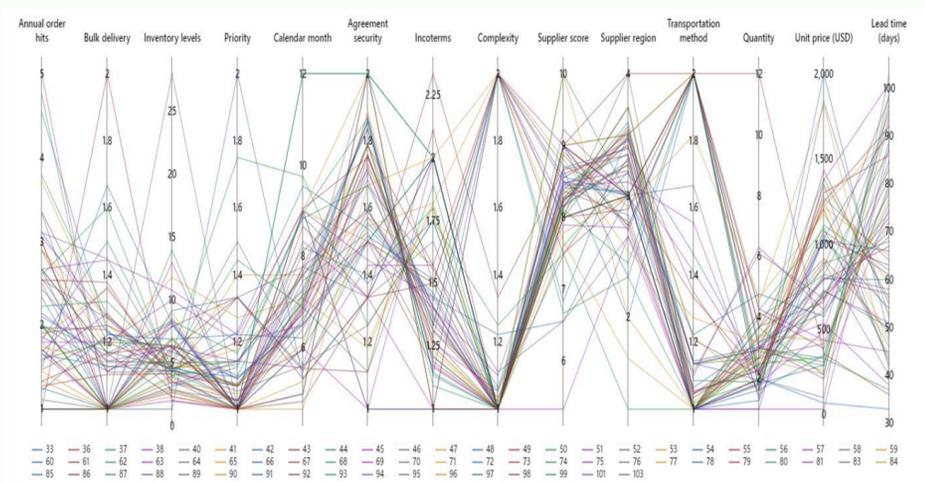**Fig. 3.** Parallel coordinate plot of the variables

Table 1. The performance measure of the proposed ML algorithms

Model	MSE	MAE	R-Square
Random Forest	20.77	3.72	0.86
Neural Network	29.73	4.35	0.81
Ensemble Model	24.19	3.95	0.84
Decision Tree	27.46	4.24	0.82
Regression	32.64	4.61	0.79

Fig. 1. Research Methodology

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EXPLORING THE INTERACTION BETWEEN MICROMOBILITY VEHICLES AND PEDESTRIANS ON SHARED PATHWAYS

Abstract
This study investigates the interactions between micromobility vehicles and pedestrians sharing pathways, focusing on several factors including pathway, vehicle and user characteristics. Field and VR experiments will be conducted to assess these factors using statistical and machine learning methods. The findings aim to provide insights into how these variables influence pedestrian-micromobility interactions.

Introduction
Micromobility vehicles have gained significant popularity in recent years due to their affordability, environmental benefits, health advantages, flexibility, and reduced parking needs [1]. As micromobility users increasingly share pathways with pedestrians, interactions between these groups have become more frequent, raising safety concerns [2]. However, a comprehensive understanding of these interactions remains limited. This study investigates the dynamics between micromobility users and pedestrians sharing pathways, focusing on factors such as pathway characteristics, and pedestrian and vehicle behavior.

Methods
A series of field and VR experiments will be conducted to analyze various factors using statistical and machine learning methods, with the goal of providing insights into the influence of these factors on pedestrian-micromobility interactions.

Results and Discussion

The anticipated project outcomes include:

1. A comprehensive insight into the interaction between micromobility vehicles and pedestrians.

2. Identification of major factors influencing diverse interactions between micromobility vehicles and pedestrians.

3. Formulation of design guidelines for shared pathways catering to micromobility vehicles and pedestrians.

Fig. 1. Pedestrian and micromobility vehicles using a shared path

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HARNESSING GRAPH THEORY AND MACHINE LEARNING FOR HYDROGEN MOBILITY SOLUTIONS

Abstract

In this research, we propose the use of graph theory and machine learning to gain insights into factors critical to hydrogen production and storage, aiming to develop a predictive model that can analyze and optimize the structural properties of materials used for hydrogen synthesis and storage. The graph representations of chemical structures, combined with their properties, will serve as the foundation to extract essential features. These features will then be provided to machine learning algorithms to predict factors contributing to optimal interactions.

Introduction

- Hydrogen has emerged as a potential clean and efficient energy carrier offering numerous environmental benefits. It has been proposed for mobility as a clean fuel for cars, helping limit the emission of pollutants and greenhouse gases that contribute to climate change. However, pure hydrogen does not exist naturally on Earth; it must be produced by separating chemical elements and stored before it can be used for mobility and other related purposes. Several challenges are associated with the production and storage processes, including optimizing production methods, identifying suitable materials for storage, and improving their capacity.

- Computational techniques, particularly AI methods, can provide a deeper understanding of how material structures influence the hydrogen evolution reaction (HER) efficiency. The representation of material structures is crucial in material informatics for achieving good predictive models. Recently, graph representations of molecules have gained attention for their robust ability to model relationships efficiently and the availability of computational tools. Molecular graph theory represents the structural formula of chemical compounds where elements are vertices and interactions are edges. This research focuses on using molecular graphs to improve HERs.

- An example of such graph representation, illustrated in Figure 1, demonstrates how the molecular structure of chemical compounds can be represented as a graph, allowing for an efficient computational approach to analyze their properties. As shown in the figure below, (a) on the left is the molecular structure visualization, and (b) on the right is the corresponding graph representation, based on the structure.
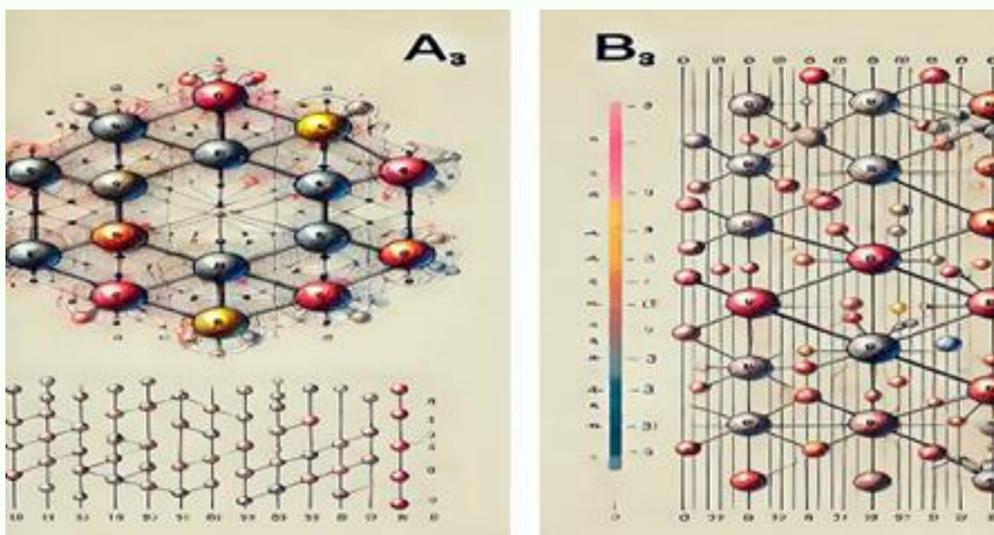

Fig. 1. Sample of molecular structure to graph representation

Methods

- Identify suitable Metal-Organic Frameworks (MOFs) from the literature.
- Obtain Crystallographic Information File (CIF) data for MOFs.
- Develop realistic graph representations for MOFs.
- Extract features such as spectral data and central tendencies from the graph.
- Test machine learning algorithms to identify relationships between predictor and target variables.
- Use the developed algorithms to make future predictions.

Results and Discussion

- We considered molecular graph representations of MOFs used for hydrogen storage, such as M-Cu-BTC and M-MOF-5, and performed numerical simulations. These simulations show that graph representations of MOFs can be effective predictors for machine learning models in estimating hydrogen uptake capacity and interaction energies.

- While the results are preliminary, they are promising. We explored multiple representations and found that feature extraction for MOFs such as M-Cu-BTC and M-MOF-5 shows encouraging results. We are currently exploring more MOFs from the literature to enhance our predictive models.

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INFORMATION-GEOMETRY-BASED BAYESIAN PARAMETER ESTIMATIONS FOR HIGH-DIMENSIONAL DYNAMICAL SYSTEMS

Abstract

This project applies information geometry, which models probability distributions as Riemannian manifolds, to develop efficient continuous-discrete projection filters for parameter estimation in stochastic dynamical systems governed by stochastic differential equations (SDEs) with discrete-time measurements. By employing Bayesian methods such as Markov chain Monte Carlo (MCMC) sampling and variational inference, the approach aims to be more scalable, accurate, and computationally efficient than existing methods. This work seeks to enhance the understanding and interpretation of dynamical systems across fields like engineering, science, and economics.

Introduction

Information geometry which is the differential-geometric approach to study statistics and information has gained popularity over the last two decades. The core concept of information geometry is to analyze the probability distributions by considering them as Riemannian manifolds. This project will study the applications of information geometry to solve continuous-discrete optimal filtering problems of stochastic dynamical systems and how to quantify the uncertainties about their parameters. Specifically, we will focus on studying the continuous-discrete projection filter for estimating the parameters of partially observed dynamical systems. The dynamical systems are assumed to be governed by stochastic differential equations (SDEs) but the measurement processes are assumed to be discrete time. The SDEs contain a finite number of unknown parameters to be estimated via Bayesian procedure using either Markov chain Monte--Carlo (MCMC) sampling methods or variational inference.

Since projection filters are generally cheaper to compute while still offering a fairly accurate approximation of filtering densities, we expect that this approach is highly scalable, accurate, and cheaper to calculate compared to the currently available methods in the literature. Due to the vast applications of the parameter estimation of the dynamical systems in engineering, science, and economy, this project will indirectly impact understanding and interpreting a large class of dynamical systems.

Project Objectives

1. Development of continuous-discrete projection filter with conjugate measurement functions for the multi-dimensional case.
2. Development of continuous-discrete projection filter with non-conjugate measurement functions for the multi-dimensional case.
3. Implementation of Riemannian MCMC for parameter estimation.
4. Development of variational-inference methods for parameter estimation.

Project Outcomes And Impact

State estimation of stochastic processes and uncertainty quantification are vital in the fields of *mobility, logistics, and transportation*. Predictive modeling and planning are fundamental in these sectors, where models are used to plan routes, schedules, and manage traffic flows. The inherent uncertainties due to factors such as weather conditions, traffic variations, and human behavior need to be accurately estimated to ensure the reliability and efficiency of these models.
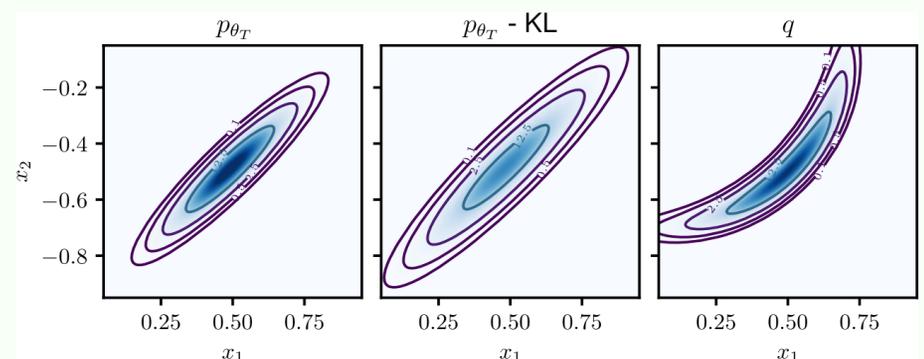
Results And Discussion

So far, we have achieved the following target:
1. Formulation of continuous-discrete projection filter for non-conjugate probability likelihood density.
2. Error analysis of continuous-discrete projection filter for conjugate family, and their comparison against state-of-the-art model.

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IRC for Smart Mobility and Logistics

KFUPM Research & Innovation Forum 2024
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King Fahd Conference Center, Building 60
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INNOVATIVE MACHINE LEARNING APPROACHES FOR HUMAN GAIT MOBILITY ANALYSIS

Introduction

Human Motion Activities analysis is beneficial in the following fields:

- Healthcare,
- Biomechanics and
- Human–Machine – Interface

It provides a non-invasive and effective way to monitor health issues and improve performance or rehabilitation outcomes.
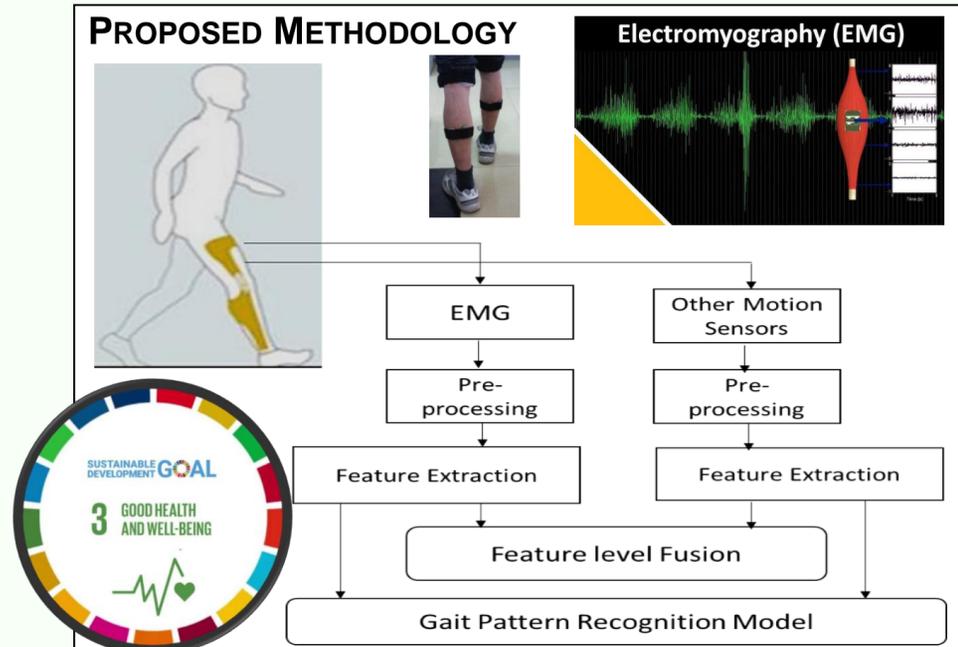
EMG and Motion Sensor based Control

- Surface electromyography (sEMG) is a non-invasive tool utilized for recording the electrical activity of muscles during dynamic tasks
- Recent research has shown that EMG-based control is the core of prostheses, orthoses, and other rehabilitation devices.
- Analysis of human kinematics during gait motion using EMG and other motion sensors is necessary to develop a robust and accurate multimodal approach for human gait analysis.
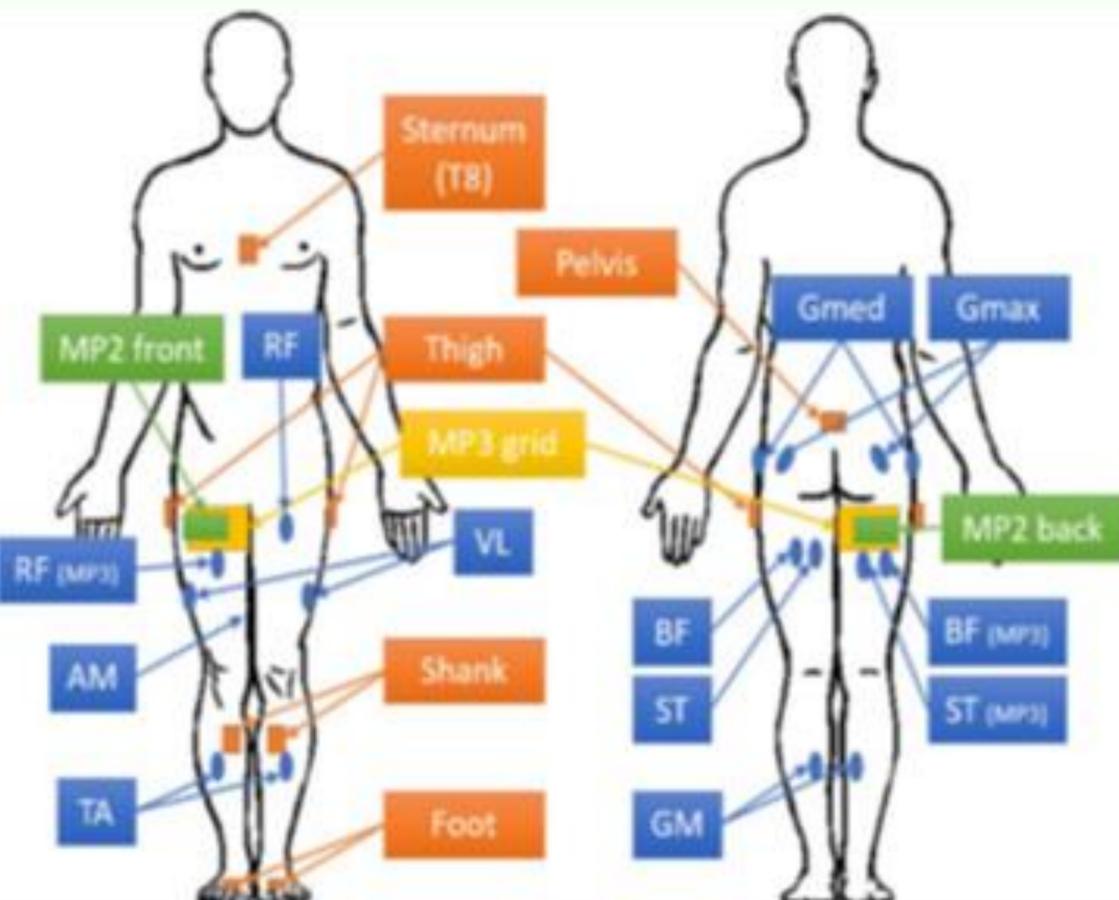
Project Objectives

- To develop a multi-model machine learning algorithm that accurately identifies human gait patterns.
- To improve the algorithm's ability to differentiate between normal and abnormal gait patterns for clinical applications.
- To enhance the generalization to overcome the vast variability of gait patterns among different individuals.
- To validate the algorithm using real-world gait data.

PROPOSED METHODOLOGY

Electromyography (EMG)

EMG → Pre-processing → Feature Extraction

Other Motion Sensors → Pre-processing → Feature Extraction

Feature level Fusion

Gait Pattern Recognition Model

SUSTAINABLE DEVELOPMENT GOAL — 3 GOOD HEALTH AND WELL-BEING

POTENTIAL APPLICATIONS

Prothesis　　**Exoskeleton**

Applications of Gait Analysis in Biomechanics

1 Clinical Assessment and Diagnosis
2 Biomechanics Research
3 Sports Performance Enhancement
4 Prosthetics and Orthotics Design
5 Ergonomics and Workplace Safety
6 Rehabilitation and Training

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(Body diagram labels: Sternum (T8), Pelvis, Thigh, MP3 grid, Shank, Foot, MP2 front, RF, RF (MP3), AM, TA, VL, Gmed, Gmax, MP2 back, BF, ST, BF (MP3), ST (MP3), GM)

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LIGHTWEIGHT AND COMPUTATIONALLY EFFICIENT YOLO FOR ROGUE UAV DETECTION IN COMPLEX BACKGROUNDS

Abstract

The growing popularity of Unmanned Air Vehicles (UAVs) for services like traffic monitoring, emergency communication, and deliveries has raised security and privacy concerns due to unauthorized drone use. To address the need for fast, efficient, and precise UAV detection under various conditions, a Lightweight and Computationally Efficient You Only Look Once (LCE-YOLO) architecture is proposed. LCE-YOLO, an enhanced version of YOLOv5s to focus on small and overlooked features critical for robust UAV detection. It is classified to have three variants, each optimized for specific feature maps, reducing computational costs while maintaining accuracy. LCE-YOLO, particularly LCE-YOLO-M, demonstrates significant performance improvements, achieving a precision of 96.8%, recall of 89.2%, mAP of 95.9%, and IoU of 50.2% in UAV detection, outperforming state-of-the-art in addressing computational complexity issues.

Introduction

Drones are widely used in communication, sensing, and surveillance; also pose significant security risks.

Detection methods: Include radio frequency signals, RADAR, imagery, and acoustic sensing, each with unique challenges such as detection range, night vision, and background noise.

Acoustic and RF detection limitations: High costs, range, and accuracy issues.

Image-based detection: Effective due to high-resolution capabilities; widely used in classification and object recognition tasks.

YOLO-based detection: Convolutional neural networks (CNNs) like YOLO are commonly used for UAV detection and outperform traditional methods.

Challenges in detection: Lightweight models, background complexity, and differentiation between UAVs and birds.

Proposed Lightweight and Computationally Efficient You Only Look Once (LCE-YOLO): An improved, lightweight version of YOLOv5s with modified kernel sizes and layer adjustments to enhance small feature extraction and scalability for UAV detection.

LCE-YOLO advantages: Optimized for binary-class classification, performs well in diverse environmental backgrounds and different-sized UAV detection, reducing false positives and improving precision.

Challenges in prior research: Lack of diverse datasets, inadequate data augmentation, weather conditions often overlooked, and limited focus on evaluation metrics.

Contributions: LCE-YOLO outperforms other models in precision, multiscale UAV targeting, and adverse weather conditions, addressing the shortcomings of prior studies.

Methods

Proposed LCE-YOLO stepwise implementation approach is summarized here:

- **Optimized Data Preparation**: The input block utilizes Mosaic Data Augmentation (MDA) and Adaptive Image Filling (AIF) to enhance the model's adaptability to diverse datasets, ensuring better generalization across different object scales and scenes.
- **Enhanced Feature Extraction**: The backbone incorporates BottleneckCSP and Spatial Pyramid Pooling (SPP), which improve the extraction of feature maps at various scales, leading to more accurate object detection in complex environments.
- **Multi-Level Feature Acquisition**: The neck block integrates Feature Pyramid Network (FPN) and Path Aggregation Network (PAN), enabling the model to capture and strengthen features from multiple layers, improving detection performance, especially for small objects.
- **Multi-Scale Detection**: Detection is performed at three scales via the head block, using downsampled input dimensions and feature maps from the 17th, 20th, and 23rd layers to handle objects of different sizes effectively.
- **Adaptive Anchor Boxes**: Specific anchor box sizes (8×8, 16×16, and 32×32) are employed to detect objects of varying scales, ensuring the model is capable of capturing small objects, such as drones and birds, in challenging conditions.
- **Refined Loss Functions**: The model applies loss functions from YOLOv5, including classification loss, objectness loss, and localization loss, combining them into a total loss to optimize detection accuracy by accounting for object presence, class probability, and bounding box precision.
- **Single-Pass Detection**: LCE-YOLO processes the input image through a single neural network pass, predicting bounding boxes for each grid cell, optimizing efficiency without sacrificing accuracy.
- **Non-Maximum Suppression (NMS)**: To prevent duplicate detections, the model uses NMS with varying kernel sizes and features across different LCE-YOLO variants, ensuring optimal detection of UAVs and small flying objects.

Results and Discussion
Dataset & Implementation

- UAV detection challenges are addressed using the LCE-YOLO architecture, with a dataset of 5000 images categorized into small, medium, and large-sized UAVs and birds for training.
- The dataset includes diverse environments and weather conditions to enhance detection accuracy in real-world scenarios, combining public drone vs. bird datasets.
- Images are pre-processed, resized, and annotated in the Roboflow-YOLO Darknet format, with a 69%-21%-10% train-validation-test split for model training and evaluation.
- LCE-YOLO-S reduces features by 60.52%, achieving the fastest inference time (8.5 ms) and highest FPS (106.7) for real-time UAV detection.
- LCE-YOLO-M shows a 95.8% precision and 94.5% mAP, outperforming YOLOv5s, YOLOv8, and YOLOv10 in UAV detection.
- LCE-YOLO excels in challenging conditions like fog and forests, making it ideal for UAV and bird detection across diverse environments.

Table 1. Performance analysis on unseen datasets.

Models	Pre-processing time (msec)	Inference time (msec)	NMS (Postprocess)/image (msec)	FPS
LCE-YOLO-S	0.2	8.5	0.7	106.7
LCE-YOLO-M	0.4	9.5	0.75	93.9
LCE-YOLO-L	0.4	17.5	0.75	53.6
YOLOv5s [14]	0.2	10.2	0.89	88.5
YOLOv8s [15]	0.4	15	0.6	62.5
YOLOv10s [16]	1.7	13.3	2.6	**109.9**

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MIXED TRAFFIC OF AUTONOMOUS AND HUMAN-DRIVEN VEHICLES ON HIGHWAYS

Abstract

A multi-level decision-making and control framework is proposed for mixed traffic of autonomous and human-driven vehicles on smart city highways, contributing to sustainable cities and communities by improving road safety, optimizing efficiency and vehicle performance in urban transportation systems.

Introduction

- Contribution: Introduce frameworks for the coexistence of Human-Driven Vehicles (HDVs) and Connected and Automated Vehicles (CAVs) using sensor fusion, distributed estimation, integrated and multi-level decision-making, and control algorithms.

- Focus: Utilize Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communication for decision-making and control to ensure smooth and efficient traffic flow under uncertainties such as changing road conditions, adverse weather, traffic disruptions, and unpredictable human driver behavior.

- Outcomes: Achieve collision-free lane changes, intelligent speed adaptation, and coordinated platoon maneuvers, such as splitting and merging for CAVs driven alongside HDVs, thereby enhancing road safety and reducing congestion, energy consumption, and emissions, which are key factors in advancing sustainable urban mobility.

Methods

- V2V communication and a decentralized algorithm account for heterogeneous platoon vehicles (Figure 1).

- Smooth trajectory generation by considering velocity constraints, collision avoidance mechanisms, and longitudinal and lateral motion control algorithms.

- A complete framework of mixed-traffic system where real-time lane change decisions are made using the Markov Decision Process (MDP), with a focus on safety, efficiency and performance (Figure 2).

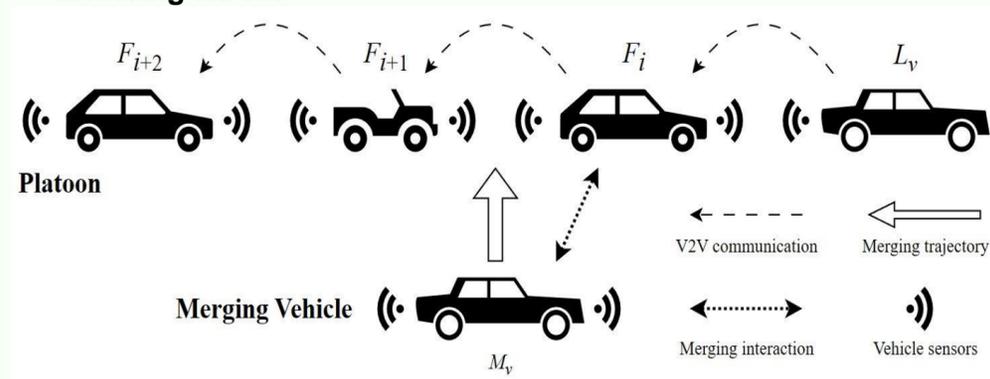- CAVs can cooperate to enable lane changes in complex scenarios involving HDVs.

Fig. 1 illustrates a platoon consisting of a leader and follower vehicles, highlighting the interaction between the merging vehicle and the platoon as it requests to join.
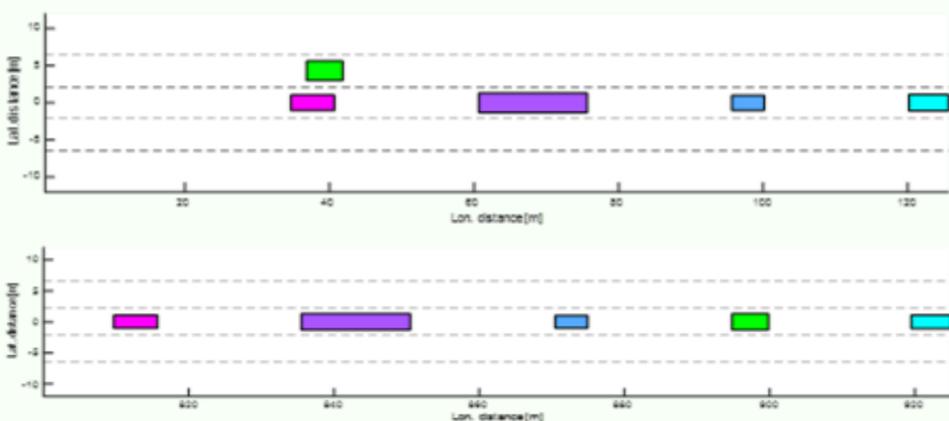

Figure 3 shows a green color vehicle joining a heterogeneous platoon using a low-communication decentralized protocol.
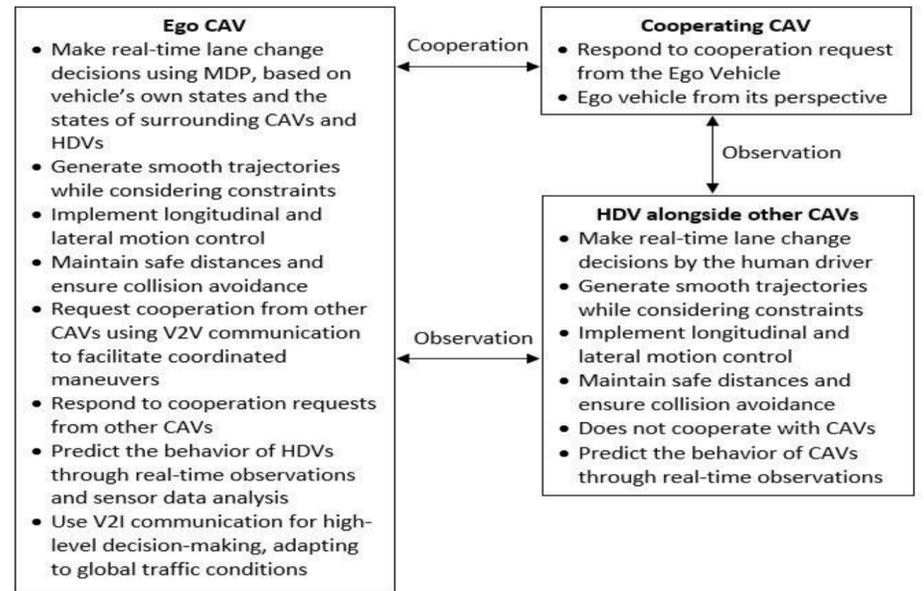

Fig. 2. presents the block diagram illustrating the functions of both Connected Autonomous Vehicles (CAVs) and Human-Driven Vehicles (HDVs) within the mixed-traffic
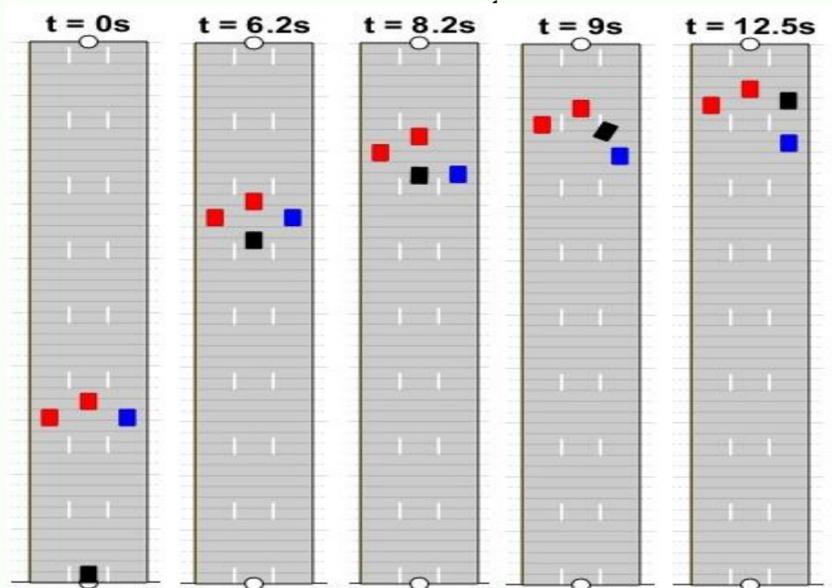

Figure 4 shows a scenario where a Black AV attempts a lane change upon receiving cooperation from the Blue AV; the Red vehicles represent non-cooperating human-driven vehicle.

Results and Discussion

- Results so far demonstrate:

- The successful merging of a new vehicle into a heterogeneous platoon is accomplished using a decentralized protocol in coordination with the vehicles already in the platoon, as illustrated in Figure 3. The merging algorithm manages both longitudinal and lateral controls to ensure the platoon formation is maintained throughout the merging process.

- Successful decision-making, trajectory generation and control for lane changes are demonstrated in a variety involving multiple CAVs and HDVs. An example of such a case is shown in Figure 4.

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OPTIMAL CONFIGURATION OF A STAND-ALONE PHOTOVOLTAIC SYSTEM BY MAXIMIZING ENERGY DENSITY CONSIDERING HYDROGEN-BASED STORAGE SOLUTIONS

Abstract

Choosing the optimal configuration and capacity planning for a hybrid PV-hydrogen system is a strategic decision-making process that spans approximately 20 years, during which climate and economic factors play a significant role. For this purpose, this research proposes a multi-objective mixed-integer nonlinear programming (MO-MINLP) optimization model that considers economic, technical, and environmental objectives. Additionally, this research utilizes the concept of conditional value at risk (CVaR) in risk management to optimize the energy density over time. The hybrid system includes decision variables such as tilt angle, spacing between PV panels, number of PV panels, number of hydrogen tanks, number of electrolyzers, number of fuel cells, and quantity of hydrogen stored over time. MO optimization helps study the trade-offs among economic, technical, and environmental objectives. We will provide a real-world case to demonstrate the practicability of the optimization model, which involves a PV-hydrogen system to supply power to the residential area at KFUPM.
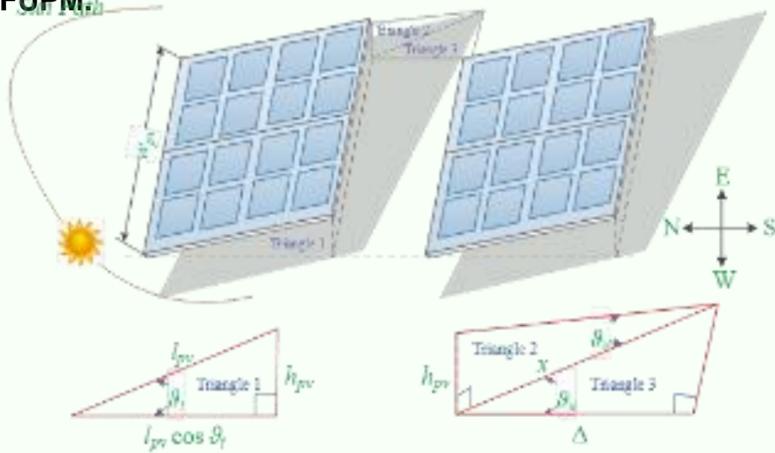
Fig. 1. Schematic representation of shading effect analysis

Introduction

- The long-term viability of sustainable infrastructures with integrated stand-alone PV systems faces several challenges. High capital expenses for renewable energy infrastructure, including PV systems, maintenance, and replacement, can hinder widespread adoption [1-3]. Renewable energy sources are intermittent, so power generation fluctuations require energy storage systems.

- PV systems hold promise, but optimizing their setup for efficiency and sustainability takes time and effort. Balancing panel orientation, tilt angles, and solar module spacing is essential. The goal is to maximize energy yield while accounting for shading, climate, and space. Efficient PV systems must adjust to changes in energy consumption and generation. Customizing installations requires careful consideration of dynamic energy demand, system configuration based on tilt and azimuth angles, and optimizing layouts for land use and sustainability [4], as shown in Figure 1.

- A hydrogen-based PV energy storage method shows promise but challenges system reliability, energy loss, and hydrogen safety. The proposed PV-hydrogen storage system includes PV modules, a hydrogen storage system, and a DC/AC inverter, as shown in Figure 2.

Methods

- A MO-MINLP model is developed to optimize the configuration and capacity planning of a hybrid PV-hydrogen renewable energy system. The methodology has two main phases:

- Phase I: Data collection and formulation of the auxiliary functions

- Phase II: Formulation and solution of the integrated model

- The proposed model's objective functions include minimizing the total life cost, maximizing the system reliability, and minimizing the loss of supply power.

The model groups the decision variables into three categories:

- **Configuration-based decisions**: spacing between PV panels, tilt angle of PV panels, and number of PV panels, H2 tanks, electrolyzers, and full cells.

- **Performance-based decisions**: the loss of the power supply and the use of a binary variable to control the charging and discharging of the hydrogen system.

- **Risk management-based decisions**: optimize energy density by considering the energy density and the expected value of scenarios below the threshold value.
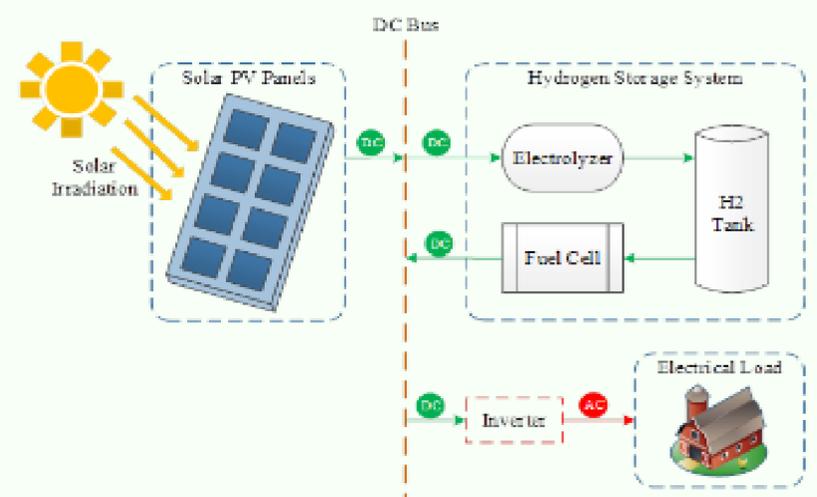

Fig. 2. Layout of a general solar-hybrid stand-alone system

Results and Discussion

- Discuss an environmentally friendly approach to meet a sustainable infrastructure's power demands.

- Suggest an optimization methodology to assist decision-makers in understanding the intricate trade-offs that govern integrated PV and H2 storage systems.

- Offer a design optimization tool that aids in sizing PV energy and H2 storage systems, considering various azimuth and elevation angles. This contributes to creating more sustainable, compact, and resilient infrastructures.

- Evaluate the performance of the proposed model through a case study involving a stand-alone PV system.

- Offer strategic recommendations based on research findings to aid decision-makers in implementing and deploying integrated PV and hydrogen storage systems.

- Assess the economic long-term viability and possibility for broad adoption of the proposed integrated system in renewable energy applications.

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OPTIMIZATION OF DRONE-LOCKER DELIVERY SYSTEM

Abstract

The growth of e-commerce and the rising of customer expectations mandates efficient design and planning of last-mile logistics. This study presents a novel delivery network design for a locker-drone system that optimizes the integration of trucks and drones to improve delivery efficiency and reduce costs. A mixed-integer linear programming (MILP) model is developed to optimize the delivery network and determine the locations for lockers, number of trucks, number of drones at each locker, and maintenance schedule. The model considers factors like drone range, locker and truck capacities, and maintenance. The study results will significantly impact the logistics and supply chain sector by streamlining the last-mile delivery process, especially in community and intra-facility contexts. It will offer a more cost-effective alternative to traditional delivery methods, thus benefiting both service providers and end-users.

Introduction

Several emerging transportation modes such as electrical vehicles, autonomous mobile robots, and autonomous drone are being used to provide fast, accurate, and safe delivery services for customers. Due to its cost-effectiveness and flexibility, drones have been implemented by several e-commerce companies such as Amazon, FedEx, and SF Express in China [1-3]. Integration of drones with last-mile logistics offers numerous benefits in terms of speed and cost-effectiveness. Trucks transport parcels from a central warehouse to lockers, from which drones complete the final delivery to customers' doorsteps [4]. However, a drone delivery system may present unique challenges that need to be addressed to fully realize its potential. For example, drone has low battery capacity which may restricts its navigation range. To address this issue, drones can be used to only ship parcels from smart lockers to final consumer while trucks can be used to ship items from main warehouses to smart lockers as shown in Figure 1.
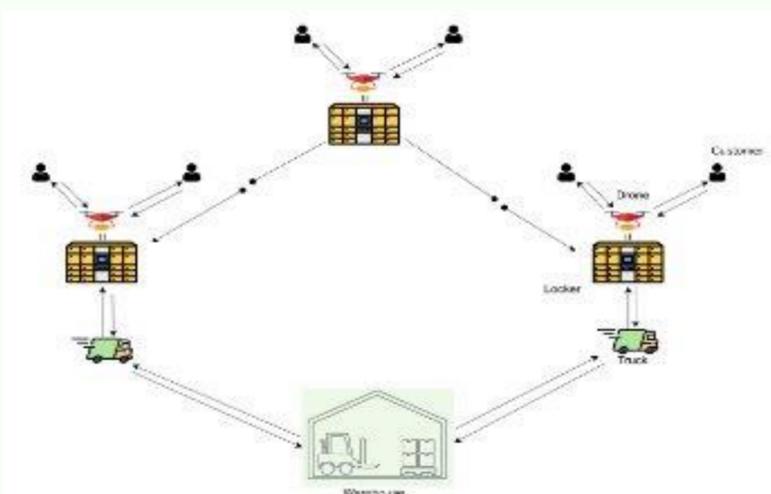

Fig. 1. Drone-locker delivery network

The maintenance of drones and trucks is crucial for the system's performance. Several authors have studied implementation of drone delivery system with last mile logistics. However, all studies focused on enhancing operational aspects, including location and routing, order assignment and scheduling. Therefore, there is a lack of studies to design network of locker-drone delivery network considering truck and drone maintenance and charging. Therefore, this study aims to develop a MILP model to design network of locker-drone delivery system and develop an efficient heuristic algorithms to solve the models.

Methods

This study aims to develop a MILP model to determine the locations for lockers, number of drones at each locker, number of trucks, and maintenance schedule. Figure 2 illustrates the research framework to achieve the study objective.
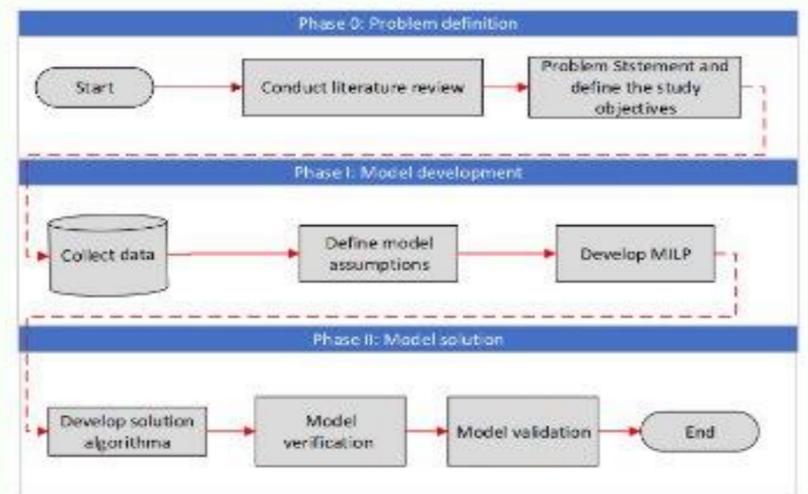

Fig. 2. Research Framework

Expected Results

The study deliverables are a MILP model and solution algorithms to optimize the locker-drone delivery network. The expected results includes determining the locations for lockers, number of trucks, number of drones at each locker, and maintenance schedule.

The study findings will influence the logistics and supply chain domain by optimizing the final-mile delivery mechanism, particularly in communal and intra-facility environments. The study will offer a cost-effective alternative to traditional delivery methods, thus benefiting both service providers and end-users.

The proposed locker-drone system aligns with the United Nations Sustainable Development Goals (SDGs) by promoting sustainable cities and communities (SDG 11) through optimized logistics that reduce environmental impact and enhance efficiency. By integrating trucks and drones, the model aims to minimize delivery times and transportation costs, contributing to responsible consumption and production (SDG 12).

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OPTIMIZING ELECTRIC VEHICLE CHARGING INFRASTRUCTURE FOR DISTRIBUTION SYSTEMS THROUGH ENERGY MANAGEMENT AND USER BEHAVIOR

Abstract

The rapid adoption of electric vehicles (EVs) presents both opportunities and challenges for distribution networks. This study explores strategies for effectively integrating EVs, focusing on grid stability, load management, and renewable energy synergy. Key factors like demand response, smart charging, and infrastructure upgrades are analyzed to ensure optimal power flow and reduced grid strain.

Introduction

This research addresses the challenge by formulating a multi-objective problem that includes charging station (CS) installation costs, network energy loss, and EV users' travel costs. To ease grid demand, photovoltaic (PV) sources will be integrated at CS nodes, with energy management strategies (EMSs) controlling battery energy storage systems (BESS). Tested on the IEEE-33 network using Monte Carlo simulations, the solution reduces energy loss and peak demand, enhancing grid stability and efficiency as EV adoption grows.

Objectives and Contributions

• Mathematical modeling of PV output energy generation and EV charging demand have been examined by considering the uncertainties in the EV driver behavior and solar irradiance. Residential, shopping, and office area loads are modeled over a 24-hour period to simulate the IEEE- 33 electrical network.
• Three approaches are modeled for the optimal location and capacity of charging for considering the benefits of EV users, CS operators, and electrical system operators.
• Furthermore, by considering the EV user approach, electrical system operator approach, and charging station operator approach, the multi-objective optimization problem is formulated with and without integrating renewable energy sources.
• Vehicle-to-grid strategy will be implemented to show its effectiveness for improving the performance parameters.
• The energy management strategies model is proposed to reduce the peak load demand of the grid and enhance the profits of the CS operator. Therefore, different energy management techniques are modeled by considering the time of use tariff and managing the battery storage units' charging and discharging states.

Framework and Methodology Process

The prime goal of this research is to enhance and improve the operational processes of future power networks by developing efficient charging techniques for EVs to ensure the reliable and stable operation of low-voltage distribution networks. The propose research work aims to analyze and address the significant power quality issues arising from the extensive integration of EVs.
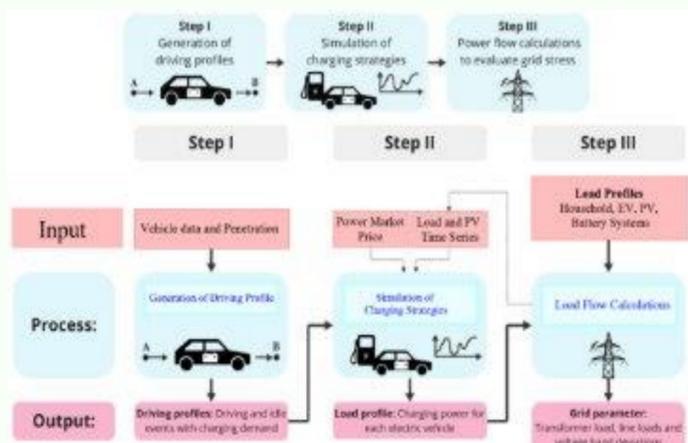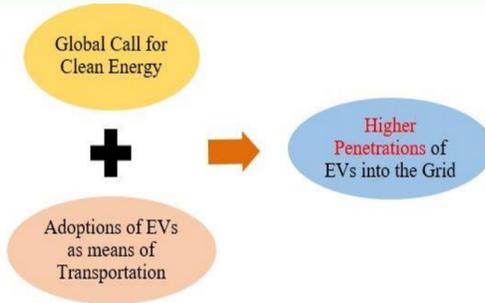

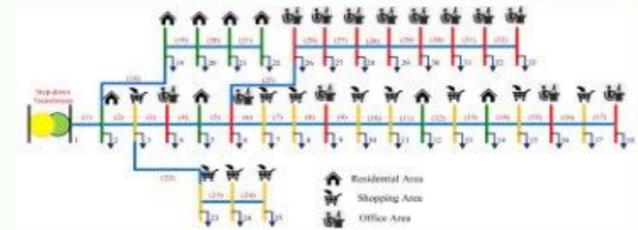Fig 1. Generalized Framework and Methodology Process Flowchart

Results

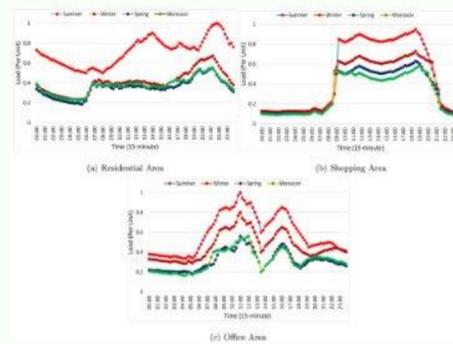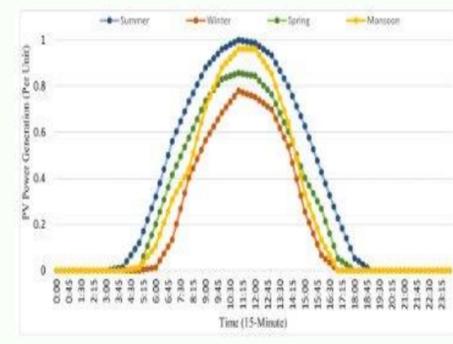Fig 2. IEEE Test Distribution Network

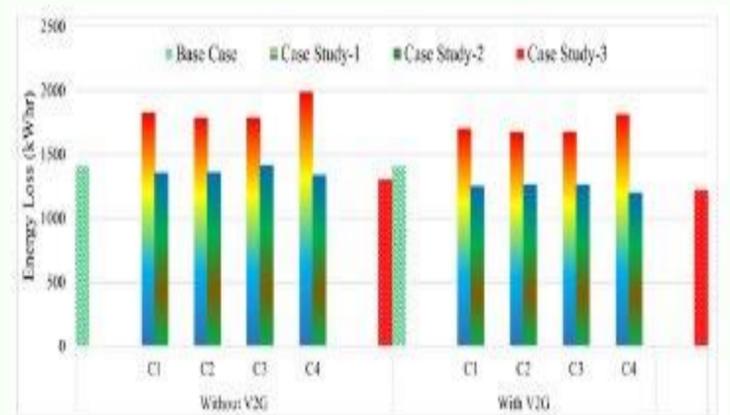Fig 3. Load Profiles

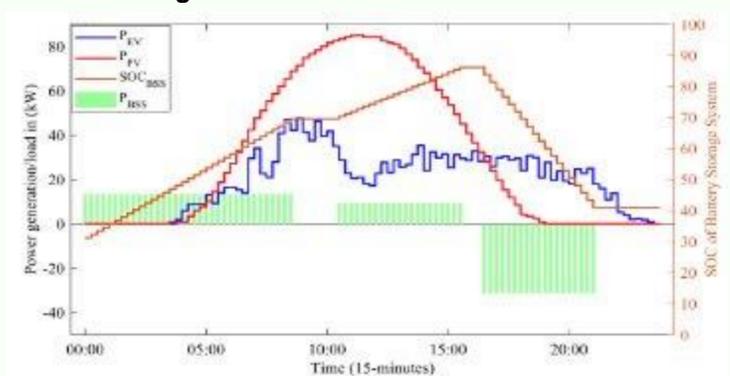Fig 4. PV Generation

Fig 5. Losses With and Without V2G

Fig 6. EV load demand, PV generation, BESS charging and discharging power with SOC after applying EMS including V2G strategy

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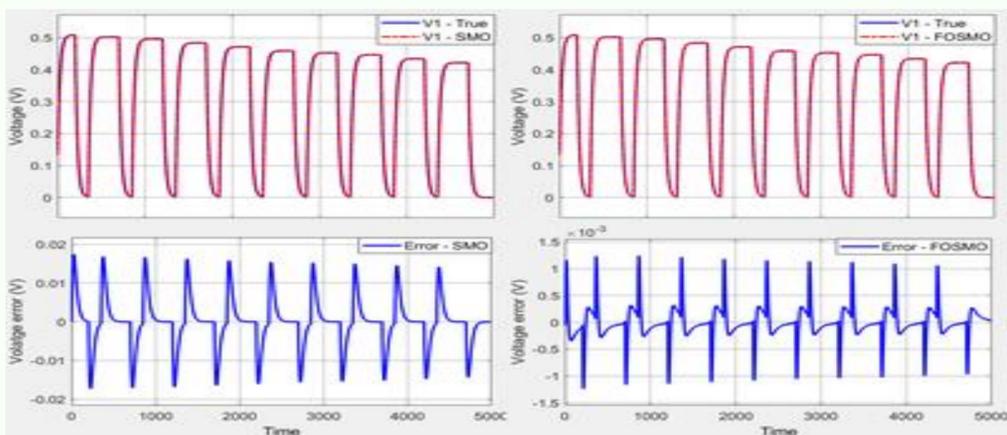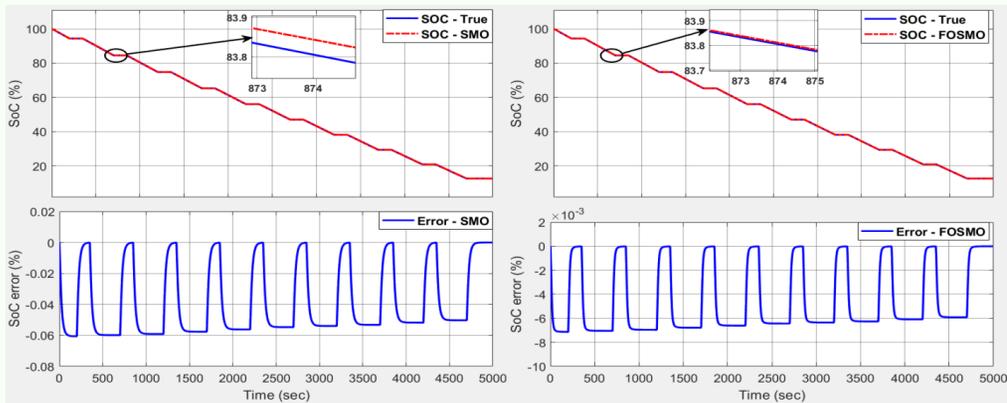### (nalyazidi@kfupm.edu.sa)

IRC for Smart Mobility and Logistics

REAL-TIME BATTERY STATE ESTIMATION AND FREQUENCY CONTROL

Abstract

This project focuses on the development of a real-time battery state estimation and voltage/frequency control system. The proposed approach integrates advanced battery management algorithms with voltage/frequency control mechanisms to enhance the reliability and efficiency of power systems. Through a combination of state-of-the-art estimation techniques and control strategies, the system aims to provide accurate state-of-charge (SOC) predictions and maintain stable frequency levels. Initial results demonstrate the effectiveness of the proposed method in both simulated and real-world scenarios, showing significant improvements in battery utilization and frequency regulation.

Introduction

The growing reliance on renewable energy sources has led to increased challenges in maintaining grid stability and efficient battery management. Accurate real-time estimation of battery state and effective V/F control is critical for ensuring the reliability and performance of power systems. This project addresses these challenges by presenting a novel approach that combines real-time battery state estimation with V/F control. By leveraging advanced estimation algorithms and control strategies, the proposed system aims to improve SOC predictions and stabilize frequency, thereby enhancing overall system efficiency and reliability.
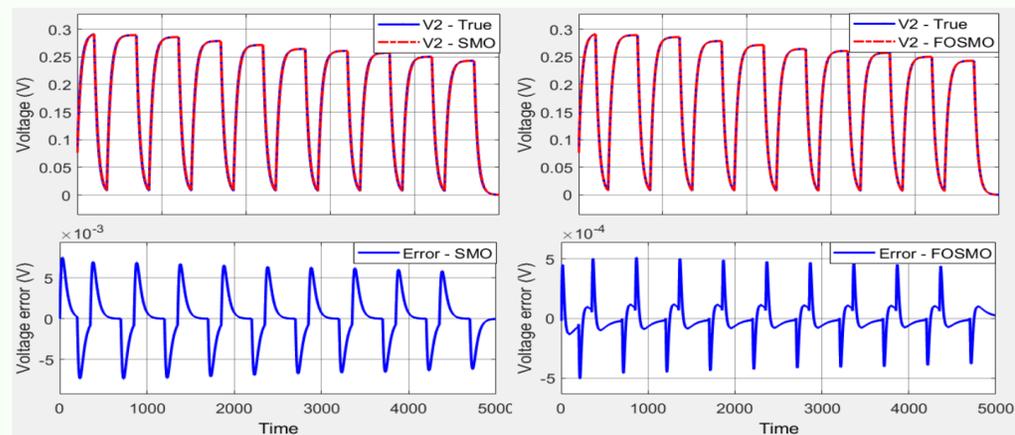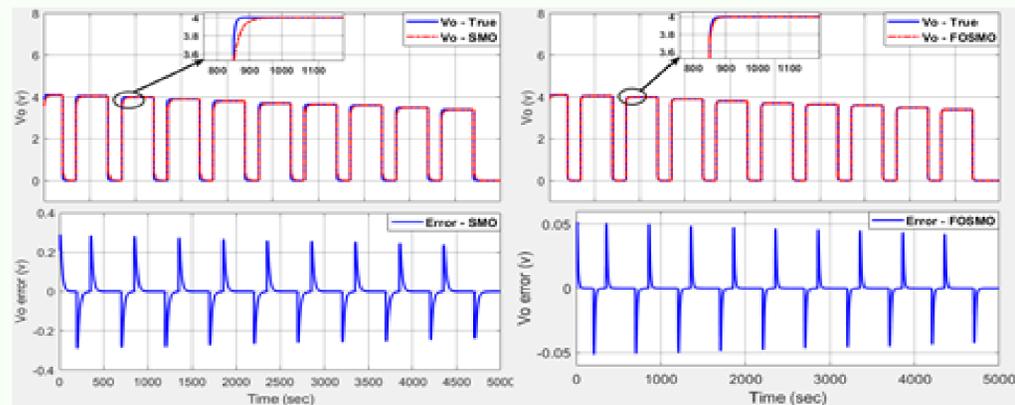
Methods

The proposed real-time battery state estimation and frequency control system comprises several key components

- **Battery State Estimation:** Utilizing techniques such as fraction order sliding mode observer and machine learning algorithms to provide accurate SOC predictions. These methods are integrated into the battery management system to continuously update the state estimates in real-time.

- **Frequency Control:** Implementing control strategies, such as a fractional order Integral Sliding mode control and Model Predictive Control (MPC), to maintain voltage/frequency stability. The control system dynamically adjusts power output based on the estimated battery state and real-time frequency measurements.

- **System Integration:** Combining the estimation and control modules into a unified system, facilitating real-time data exchange and coordinated operation. This integration ensures that SOC predictions inform frequency control actions, optimizing both battery utilization and grid stability.

Results and Discussion

The actual and estimated values of output Vo and Soc and their errors between them under SMO and FOSMO are shown in Figures The actual and estimated values and their errors for various variables. This study, in line with previous studies on the state-of-charge assessment of lithium-ion batteries, used a pulse signal for current, with amplitude, period, and pulse width up to 5 amps, 500 seconds, and 30%, respectively. Figure 2d shows the true and estimated Voc together with the estimated error.

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- **[3]. Nuroldayeva, G., Serik, Y., Adair, D., Uzakbaiuly, B., & Bakenov, Z. (2023). State of Health Estimation Methods for Lithium-Ion Batteries. International Journal of Energy Research, 2023.**

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IRC for Smart Mobility and Logistics

ROBUST DYNAMIC EVENT-TRIGGERED FORMATION CONTROL OF MULTIAGENT SYSTEM

Abstract

This project presents a novel dynamic event-triggered formation control scheme for multiagent systems, with a specific focus on UAVs. Unlike traditional methods, which rely on pre-determined reference trajectories, we introduce an adaptive approach where the leader agent generates a real-time flexible reference trajectory by incorporating an unknown input signal. This allows the leader to dynamically adjust its trajectory in response to environmental changes, obstacles, or mission variations. The proposed robust control framework employs event-triggered mechanisms that optimize communication bandwidth, significantly reducing the need for continuous information exchange between agents.

The novelty of this project lies in the integration of dynamic event-triggered mechanisms with leader-state compensators to enhance the robustness and flexibility of the multiagent system. Our approach ensures efficient time-varying formation tracking, even in the presence of uncertainties and disturbances.

Through extensive MATLAB/Simulink simulations, we demonstrate the superiority of this method over conventional techniques. The expected outcomes include the development of a comprehensive database of formation control strategies and the publication of findings in high-impact journals and conferences. This work will contribute to advancing the state-of-the-art in UAV formation control, with potential applications in autonomous systems, surveillance, and disaster response.

Introduction

The increasing complexity and demand for precision in multiagent systems, particularly in autonomous applications such as unmanned aerial vehicles (UAVs), has driven the need for more adaptive and efficient control strategies. Traditional formation control approaches often rely on pre-determined reference trajectories, which limit the system's ability to respond to dynamic environments, uncertainties, and unplanned events. Moreover, continuous communication between agents results in excessive bandwidth consumption, which is not feasible for large-scale systems.

- This project addresses these challenges by developing a novel dynamic event-triggered formation control scheme that optimizes communication and enhances the robustness of multiagent systems. Unlike conventional methods, the proposed control framework introduces a flexible leader agent that can dynamically adjust its trajectory based on an unknown input signal. This allows for real-time adaptation to environmental changes, obstacle navigation, and mission re-planning. The use of event-triggered mechanisms minimizes unnecessary data transmission, conserving communication resources while ensuring accurate formation tracking.

- Our approach is designed to handle time-varying formations, even in the presence of external disturbances and uncertainties. By implementing this control strategy on a fleet of UAVs, the project aims to demonstrate significant improvements in system agility, responsiveness, and robustness compared to existing techniques.

Expected Results

- **Improved Formation Control:** The project is expected to demonstrate significant improvements in the formation control of multiagent systems, particularly in adapting to time-varying environments and mission changes.

- **Communication Efficiency:** By employing event-triggered mechanisms, we anticipate a substantial reduction in communication bandwidth usage, leading to more scalable and efficient multiagent systems.

- **Robust Performance:** The proposed control scheme will enhance the robustness of UAVs in handling uncertainties and disturbances, ensuring reliable formation tracking in dynamic environments.

- **Simulation Validation:** Through extensive MATLAB/Simulink simulations, the superiority of the proposed method will be validated against conventional formation control approaches, showcasing its adaptability and efficiency.

- **Research Output:** The project will contribute to developing a database on formation control strategies, and the results will be published in two ISI Journals and presented at two Scopus-indexed conferences.

References

1. Najib Alabsari, et.al., "Cooperative Flight Control of a Fleet of Quadrotors Using Fractional Sliding Mode With Potential Field Algorithms", in IEEE Access, vol. 12, pp. 24525-24543, 2024, doi: 10.1109/ACCESS.2024.3362976.

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ROBUST ISMC CONTROL OF PEM FUEL CELL VOLTAGE FOR H2 VEHICLE

Abstract

Maintaining precise output voltage is critical for optimal performance in Proton Exchange Membrane (PEM) fuel cell systems, a cornerstone technology in hydrogen-based vehicles. This research introduces a robust adaptive fixed-time integral sliding mode control (FxT ISMC) strategy to address voltage regulation challenges caused by uncertainties in load and input voltage. FxT ISMC eliminates the need for pre-defined disturbance bounds through adaptive gains and therefore simplifies the implementation. The ISMC design guarantees robust and rapid convergence to the desired voltage, regardless of initial conditions, ensuring smooth power delivery for the electric motor in a hydrogen vehicle. The benefits include faster voltage regulation, lower voltage spikes, reduced control oscillations, and exceptional resilience to fluctuations, ultimately contributing to a more efficient and reliable method of propulsion in hydrogen-powered vehicles.

FCVs show promise for Saudi Arabia's clean transport goals, but they are still in the early stages of development.
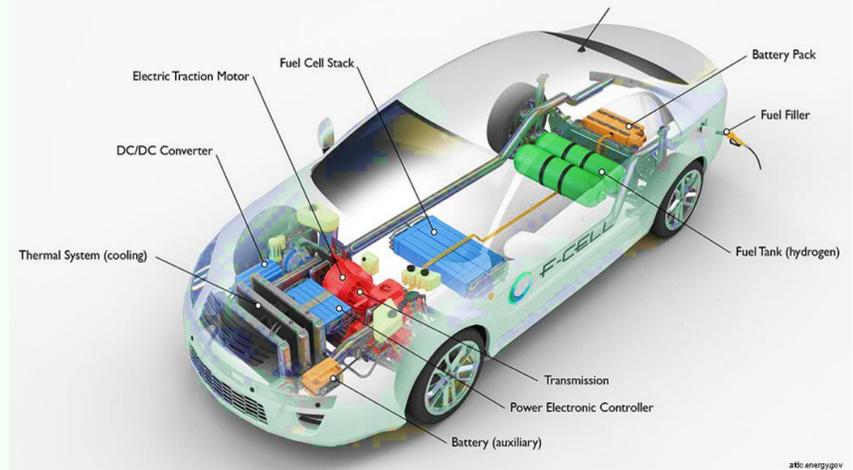

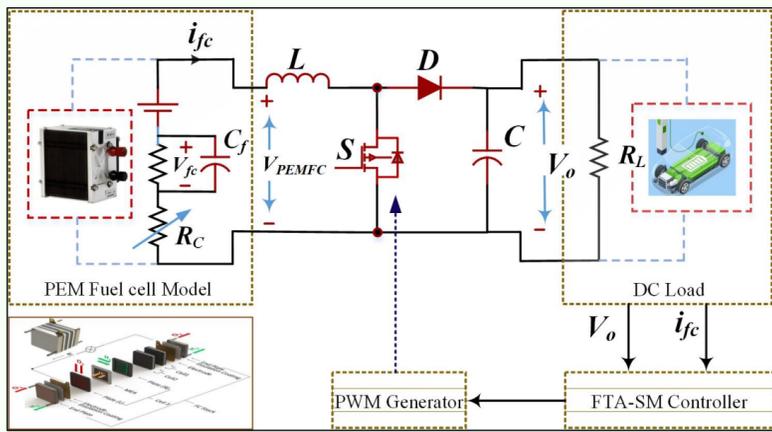Fig. The internal architecture of a Hydrogen based Fuel cell electric vehicle

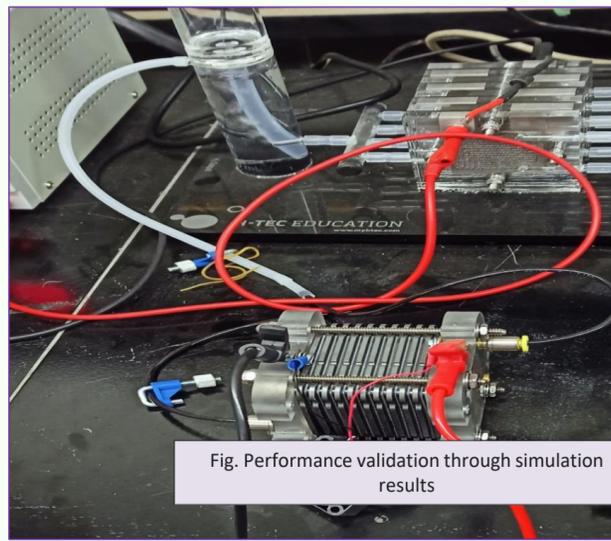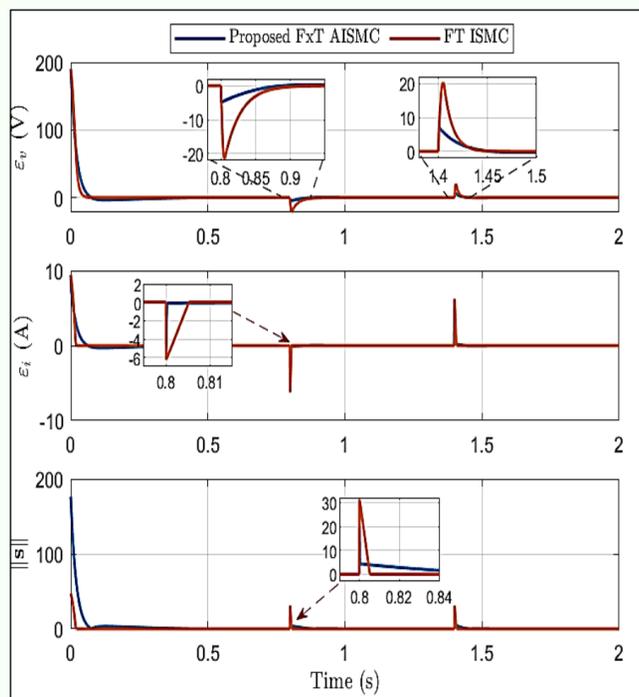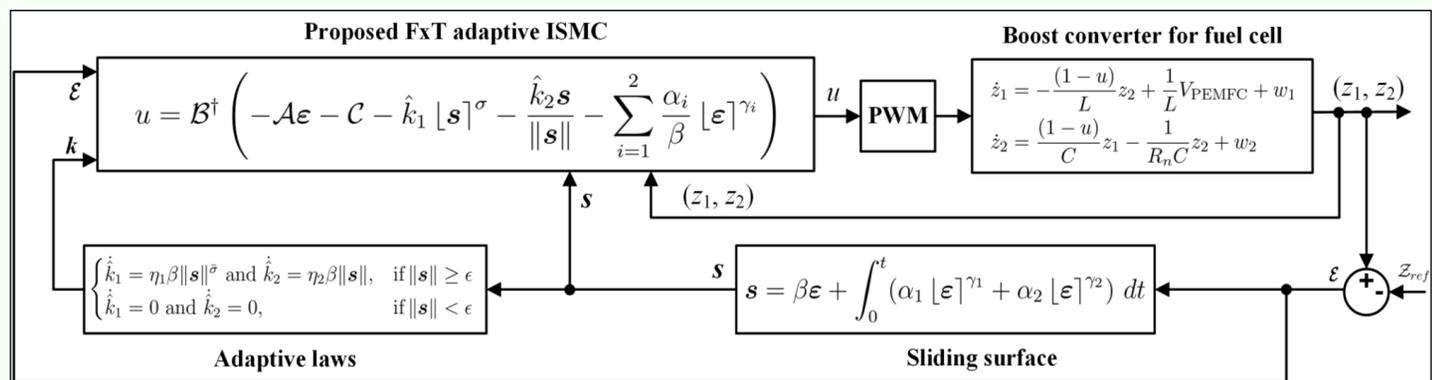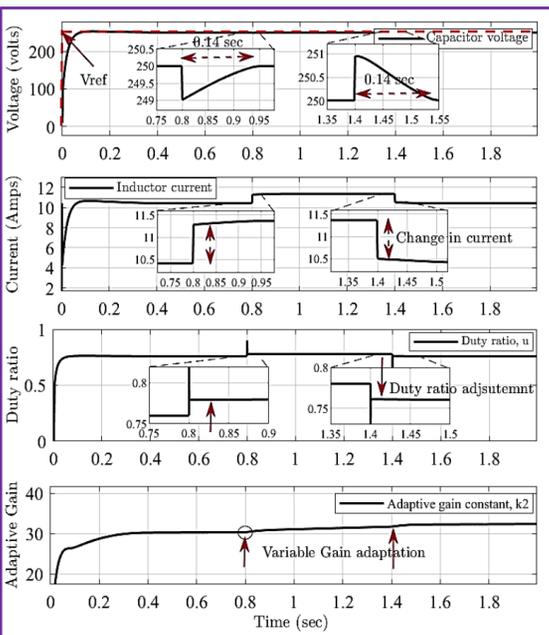Fig. Block diagram representing the fuel cell and the dc-dc converter

Fig. Performance validation through simulation results

Proposed FxT adaptive ISMC

$$u = \mathcal{B}^\dagger \left(-\mathcal{A}\varepsilon - \mathcal{C} - \hat{k}_1 \lfloor s \rceil^\sigma - \frac{\hat{k}_2 s}{\|s\|} - \sum_{i=1}^{2} \frac{\alpha_i}{\beta} \lfloor \varepsilon \rceil^{\gamma_i} \right)$$

Boost converter for fuel cell

$$\dot{z}_1 = -\frac{(1-u)}{L}z_2 + \frac{1}{L}V_{PEMFC} + w_1$$
$$\dot{z}_2 = \frac{(1-u)}{C}z_1 - \frac{1}{R_n C}z_2 + w_2$$

Adaptive laws
$$\begin{cases} \dot{\hat{k}}_1 = \eta_1\beta\|s\|^{\hat{\sigma}} \text{ and } \dot{\hat{k}}_2 = \eta_2\beta\|s\|, & \text{if } \|s\| \geq \epsilon \\ \dot{\hat{k}}_1 = 0 \text{ and } \dot{\hat{k}}_2 = 0, & \text{if } \|s\| < \epsilon \end{cases}$$

Sliding surface
$$s = \beta\varepsilon + \int_0^t \left(\alpha_1 \lfloor \varepsilon \rceil^{\gamma_1} + \alpha_2 \lfloor \varepsilon \rceil^{\gamma_2}\right) dt$$
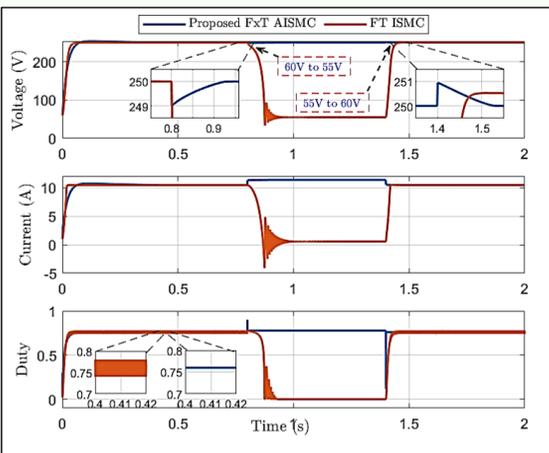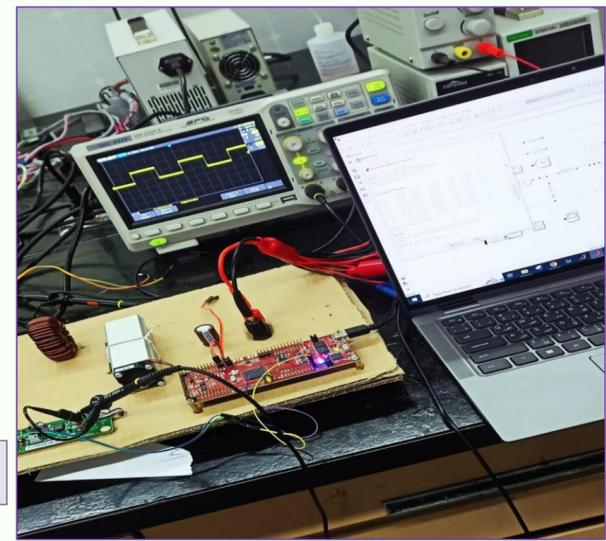
Error performance measures of voltage and current under different conditions.

Control Schemes	For voltage error (ε_v) performance				For current error (ε_i) performance			
	ISE	IAE	ITSE	ITAE	ISE	IAE	ITSE	ITAE
Case 1	Variation in load resistance							
Finite time ISMC	404.2653	3.9914	12.9389	0.9116	0.8478	0.1403	0.1619	0.0426
Proposed FxT AISMC	359.4209	4.4893	4.6645	0.5314	0.6586	0.2102	0.0245	0.0271
Case 2	Fluctuation in input voltage							
Finite time ISMC	20907.04	111.7053	23396.04	123.7164	65.3636	6.2373	73.0207	6.9238
Proposed FxT AISMC	358.5273	4.2801	3.6737	0.3101	0.6462	0.2063	0.0080	0.0213

References

1. World Hydrogen Forum. (n.d.). https://worldhydrogenforum.com/
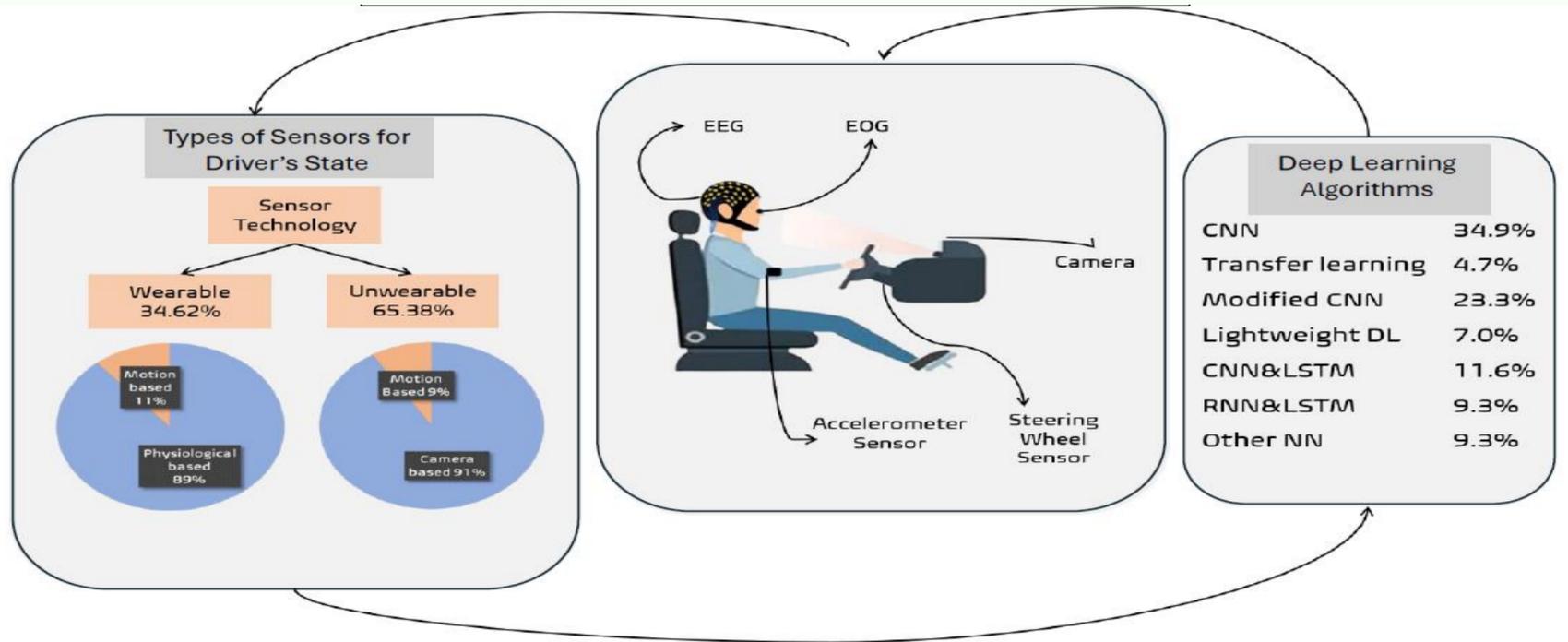2. Xu, Jiang-Hai, et al. "Sliding mode–Extended state observer control strategy to improve energy transfer of PEMFC connected DC-DC boost converter system." *Sustainable Energy Technologies and Assessments* 63 (2024): 103654.
3. Chen, Wenjie, et al. "Optimal power and energy management control for hybrid fuel cell-fed shipboard DC microgrid." *IEEE Transactions on Intelligent Transportation Systems* (2023)..
4. Cavo, M., et al. "An advanced control method for fuel cells-Metal hydrides thermal management on the first Italian hydrogen propulsion ship." *International Journal of Hydrogen Energy* 48.54 (2023): 20923-20934.

Fig. Performance validation through simulation results

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KFUPM Research & Innovation Forum 2024
Oct 1st − 3rd , 2024
King Fahd Conference Center, Building 60
KFUPM, Dhahran, Saudi Arabia

IRC for Smart Mobility and Logistics

SENSORS TECHNOLOGIES FOR DRIVER' STATE DETECTION

GENERAL OVERVIEW

INTRODUCTION

- **Several studies reveal that, 75% of the road accidents are related to the driver's behavior.**
- **Fatigue and drowsiness are the two main factor influence the driver's behavior.**
- **To alleviate these fatal accident, driver's state should be monitored**
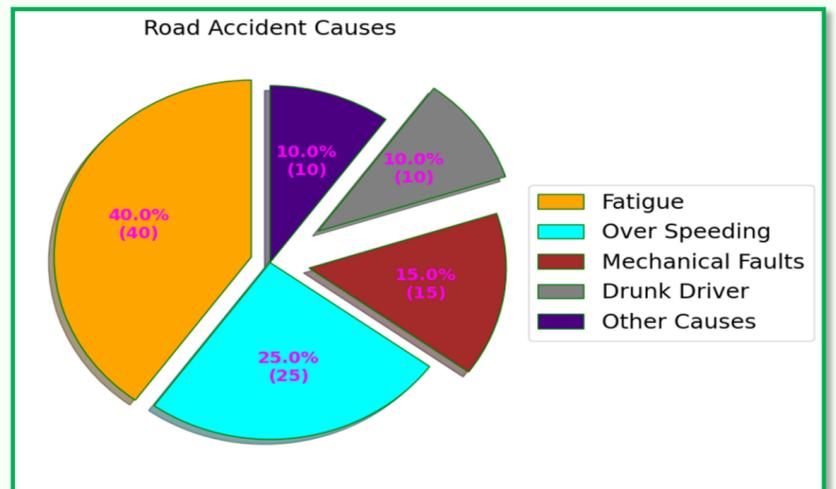
FATIGUE DETECTION TECHNIQUES

| Technique	Measure	Pros	Cons
subjective	Questionnaire	Subjective	Not applicable in real time
Imaged or video-based	Camera	Nonintrusive	Lighting conditions
physiological-based	EEG, ECG, EOG,	Reliable Accurate	Intrusive
Vehicle-based	lane position Wheel movement	Nonintrusive, Reliable	Unreliable

- **The usage of unwearable sensors technology for the fatigue and drowsiness detection**
- **Because of its non-intrusive capabilities for capturing the drivers' state.**
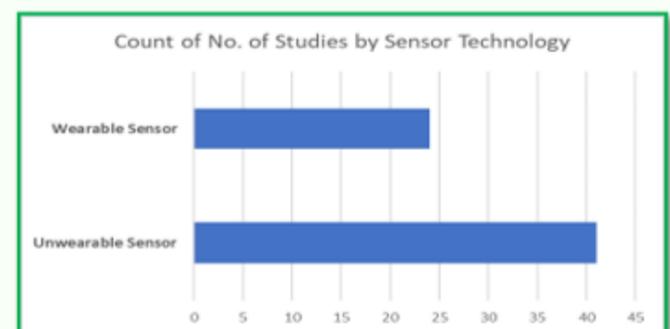
SENSOR TECHNOLOGY
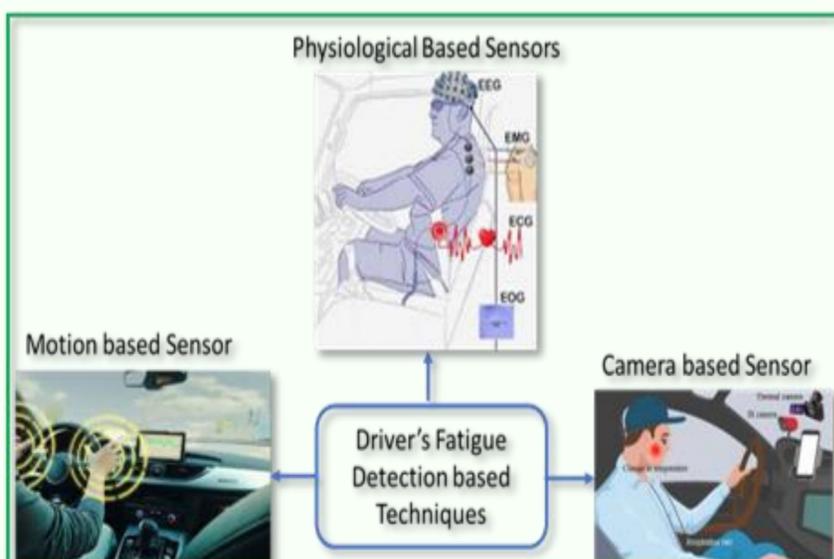
Deep Learning based Detection Algorithms

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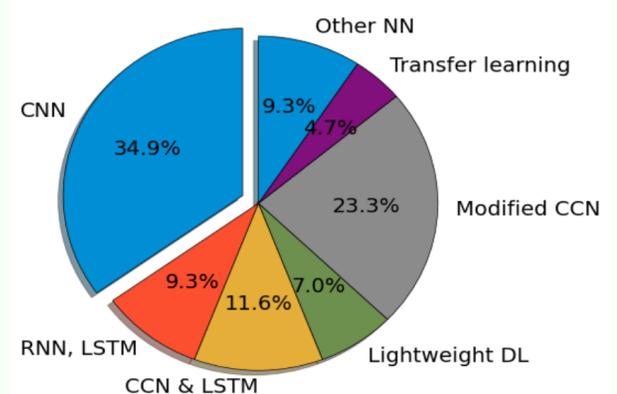
SUSTAINABLE CAMPUS MOBILITY: EVALUATING AND ENHANCING WALKABILITY THROUGH VIRTUAL REALITY

Abstract

Campus walkability plays a critical role in promoting physical activity and improving the quality of life. This research explores the use of virtual reality (VR) as a tool to evaluate and improve walking experience. Using a wearable vr headset, participants navigated various urban design scenarios, providing real-time feedback on their walking experience. The study aims to promote sustainability and encourage physical activity by identifying key design interventions that align with user preferences and needs.

Introduction

Environmental challenges are driving higher education institutions (HEIs) to adopt sustainability initiatives [1]. Campus walkability is key to promoting physical activity, which offers social, environmental, and health benefits [2]. However, a decline in physical activity on campuses has been observed due to factors such as inadequate walking infrastructure, poor design elements, and user intentions. Additionally, campuses, especially in arid regions like Saudi Arabia, often face obstacles such as extreme heat and inadequate infrastructure that hinder walking behavior.
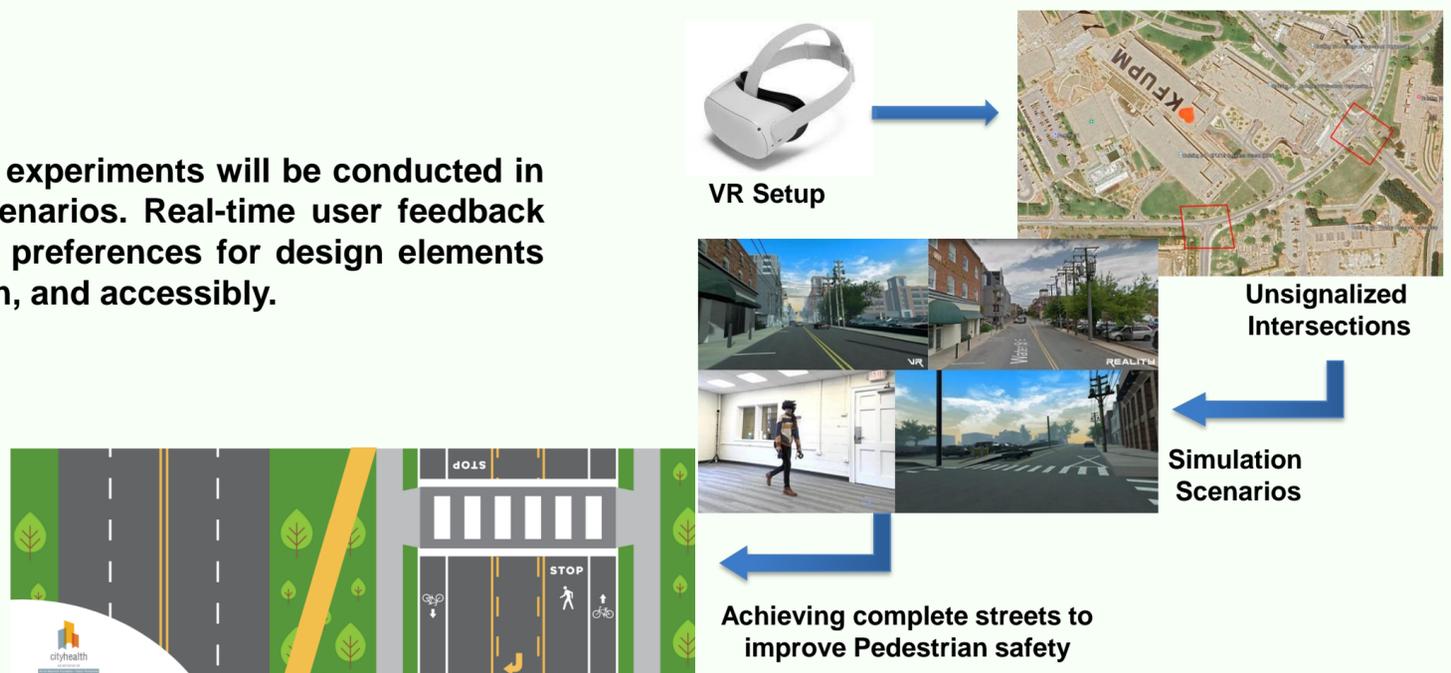
This study uses Virtual Reality (VR) to assess and improve campus walkability, exploring design interventions to enhance walking behavior and contribute to a more sustainable and accessible campus.

Methods

A series of VR head mount experiments will be conducted in various campus design scenarios. Real-time user feedback will be collected to assess preferences for design elements such as shading, pedestrian, and accessibly.

Results and Discussion

1. **Design Preferences:** Identify major design preferences of the users to promote on campus active mobility.

2. **Sustainability:** Encouraging walking behavior through design improvements and reducing reliance on motorized transport.

3. **Health & Well-being:** Improving walking experience is expected to increase physical activity levels, promoting better health outcomes for students, faculty, and staff.

VR Setup

Unsignalized Intersections

Simulation Scenarios

Achieving complete streets to improve Pedestrian safety

References

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UAV - Manipulator Systems: Modelling and Control Design

Abstract

UAV-Manipulator system, in which a robotic arm with N-DOFs (N=1,2, 3,…n) is attached to the unmanned aerial vehicle UAV system with 6-DOFs. Recently, UAVs systems are getting remarkable attention from researchers due to their daily involvement in many applications including both sectors: military and civilian. The UAV-Manipulator flying system will add more significance features which result in expanding the applications to include such as, package handling, infrastructure inspection, assembling, maintenance, repair, contingency operations, irrigation monitoring, Palm pollination, and delivering medical logistics. UAV-Manipulator flying system is classified as multibody dynamics systems, with high nonlinearity, and coupled dynamics. The scope of this research project will cover the theoretical background, simulation tests, and experimental validation for the flying robotic arm system.

Introduction

- This research aims to magnify the benefits from UAVs systems and make it more impactful and smarter in terms of indoor and outdoor environment applications. Therefore, a rigid robotic arm manipulator with N-DOFs will be attached to UAV with 6-DOFs to come up with a proposed UAV-Manipulator system with (6+N) DOFs. As a result, the UAV-Manipulator system offers more degree of freedom compared to standalone UAV system. The classical UAV systems applications revolve around such as monitoring, inspection, remote sensing, and so on. However, in addition to prior mentioned, the potential of UAV-Manipulator systems applications can be extended to include such as maintenance, repair, Palm pollination, delivering medical logistics, rescue, package handling, and much more.

- Considering that the proposed UAV-Manipulator systems mostly operate in outdoor harsh environment such as industrial areas, to execute complex operations like maintenance or repair, where the external disturbance and parameters uncertainties are existing, all these challenges, must be considered in control design phase. Therefore, the major aim in this project to design a robust and intelligent control algorithm that enable UAV-Manipulator system to execute the assigned tasks that require physical interaction with the environment precisely and successfully. The work in this project includes two major parts, simulations, and experiment. The simulation can be carried out by using MATLAB/SIMULINK, or Python. While, a physical prototype of UAV-Manipulator control systems will be developed and validated in the laboratory.

- The developed UAV-Manipulator model and the designed control scheme will be benchmarked with the current and existing models that recently reported in the literature review, and evaluating the performance of the proposed control scheme in terms of trajectory tracking error, particularly in the presence of the external disturbance and parameters uncertainties.
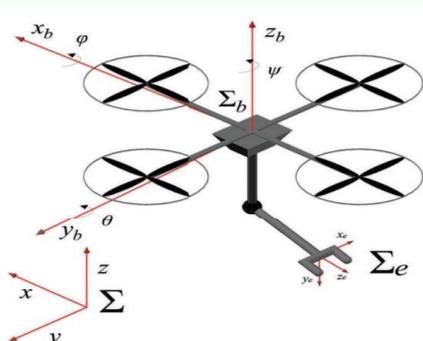
Methods

- This project will be multidisciplinary project from fields such as control systems engineering, control theory, machine learning, and optimization techniques. The team members will include researchers, postdocs, postgraduate students, technicians & secretary (for documentation). The project life cycle can be planned and divided in to the below five major phases:

- Phase 1: Data collection and analysis, this phase will study the previous works that have been reported in the literature for the robotics arm, and UAV systems in terms of mathematical modeling, control design implementation, and experimental validation. The expected deliverables at the end of this phase is to prepare a comprehensive review paper for a journal submission.

- Phase 2: Model development and validation, this phase will be mainly focused on the mathematical modeling development of the UAV-Manipulator flying system using software tools such as MATLAB/Simulink, Python, ROS2 and SLAM, then building a physical prototype for the UAV-Manipulator flying system for experimental validation. The expected deliverables at the end of this phase is to have an accurate mathematical model, and prototype for the UAV-Manipulator flying system that will be used to perform control strategies design, and implementation.

- Phase 3: Control strategy design and implementation, this phase will be mainly focused on designing a novel and robust control strategy for the UAV-Manipulator flying system to execute given tasks precisely with a minimum error, where the performance of the proposed control scheme will be benchmarked with existed current design. The expected deliverables at the end of this phase is to prepare a technical high-quality paper for a journal submission.

- Phase 4: Test, this phase will be dedicated for extensive tests and evaluation (experimentally) for the performance of the proposed control strategies for the UAV-Manipulator flying system, the test will include different scenarios and real applications such as indoor and outdoor operation environments. The expected deliverables at the end of this phase is to have real prototype UAV-Manipulator flying system available in the laboratory, and prepare a technical high-quality paper for a journal submission.

- Phase 5: Closure, in this phase a comprehensive document will be prepared including such as final report, invoices, publication outcomes, and a complete prototype for the UAV-Manipulator flying system.

Expected Result

- Mathematical Model Development: A comprehensive and validated model for the UAV-Manipulator system that accurately captures dynamics, disturbances (e.g., wind gusts), and parameter uncertainties.

- Control System Design: A novel, robust control algorithm based on adaptive control and AI techniques that can stabilize the UAV-Manipulator and minimize tracking errors under different operational scenarios.

- Prototype and Experimental Validation: A physical prototype of the UAV-Manipulator system, tested in both indoor and outdoor environments.

- The proposed control system will be benchmarked against existing models, evaluating performance based on metrics such as trajectory tracking accuracy, response to disturbances, and task execution success

Figure 1 Quadcopter UAV and robotic arm system with the corresponding frames [7].

Figure 2 Example of Multi-Body dynamics system for Hexa-Rotors and Duel 2-DOFs robotic arms.

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IRC for Smart Mobility and Logistics

WIDE RANGE HIGH GAIN CONVERTER FOR H_2 BASED VEHICLE

Abstract

This poster presents a wide-range high-gain DC-DC converter designed for hydrogen-based vehicles. The proposed converter overcomes the limitations of conventional boost converters, which face significant challenges at high voltage levels, such as high duty ratios, excessive component stress, and increased switching losses. By incorporating extended design elements and double duty cycles, this converter achieves high voltage gain with reduced stress on components, continuous input current, and a flexible operating range. The converter's performance is validated through experiments on a 600W prototype, demonstrating its effectiveness for high-voltage applications.

Methodology and results
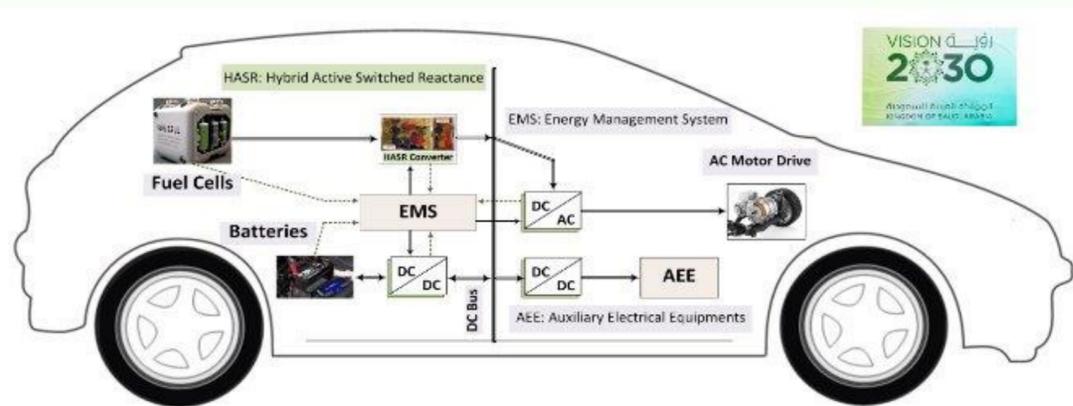
Fig. 1. The internal architecture of a Hydrogen based Fuel cell electric vehicle (FCEV)
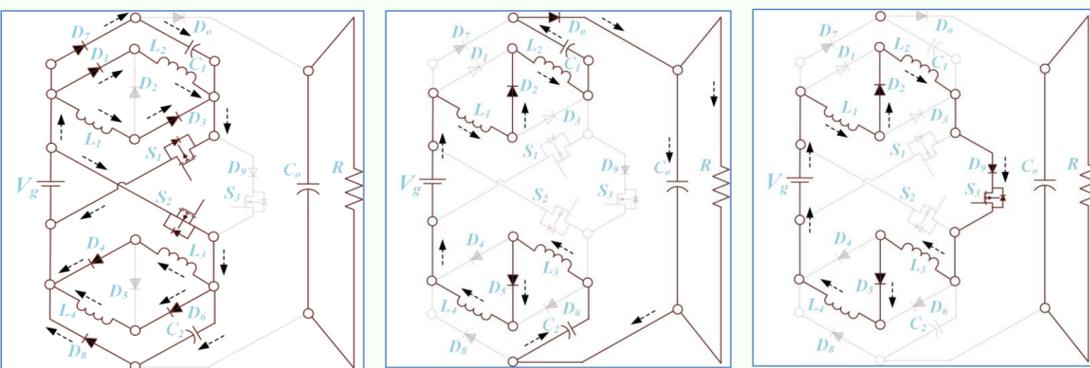
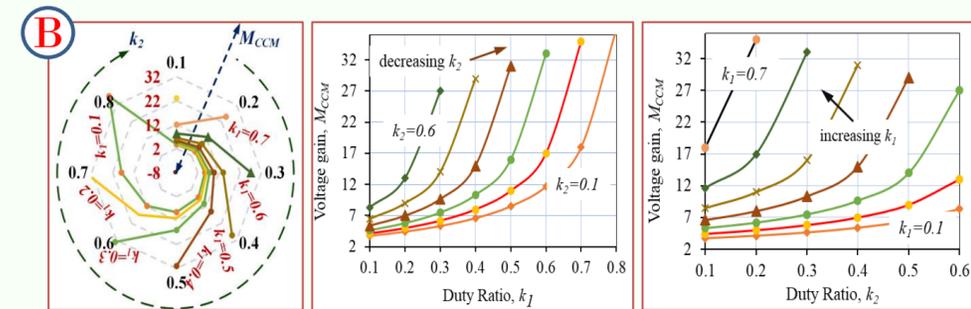Fig. 2. The three modes of operation with two duty cycles, k_1 and k_2
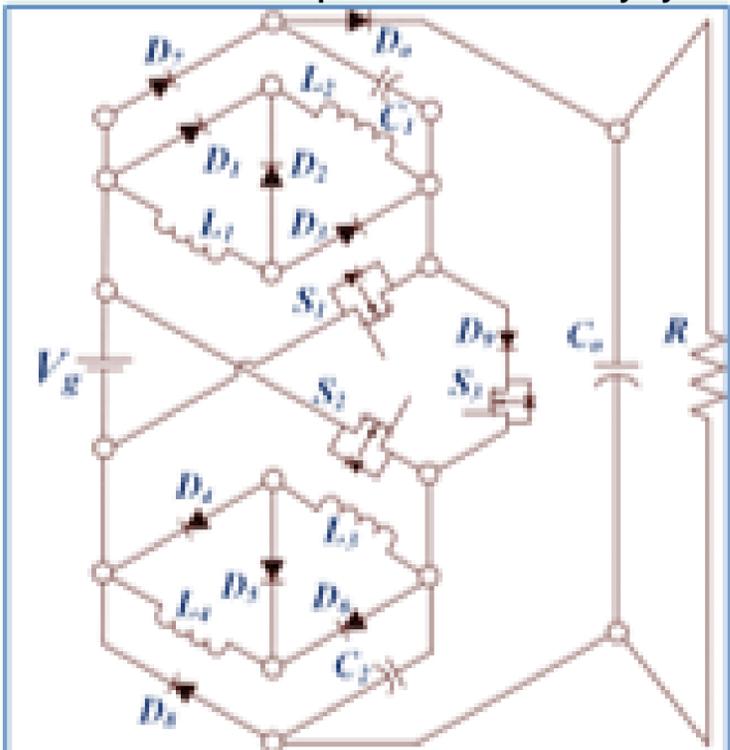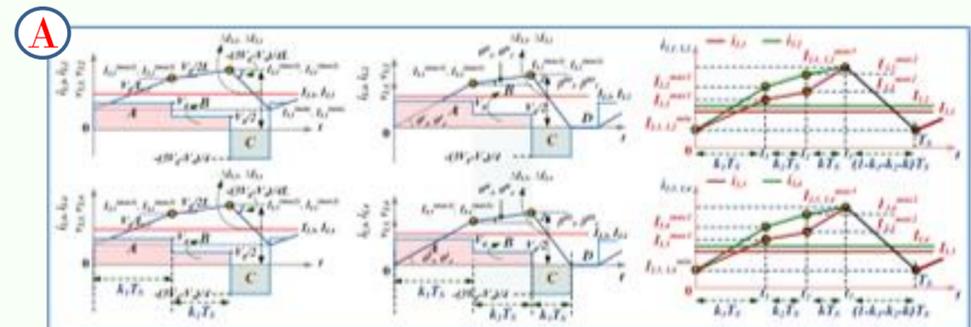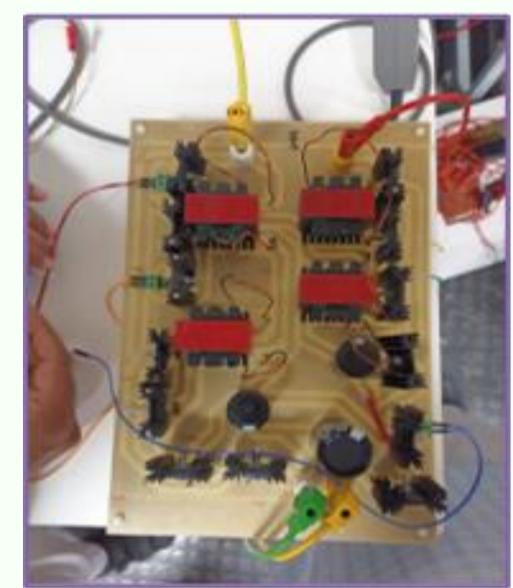

Fig. 3. The Proposed DC-DC converter for FCEV

Fig. 3. The Experimental Prototype

$$M_{CCM} = \frac{V_o}{V_g} = \frac{3 + k_1 - k_2}{1 - k_1 - k_2}$$

$$M_{DCM} = \frac{V_o}{V_g} = \frac{3}{2} + \sqrt{\frac{9}{4} + \frac{(2k_1 + k_2)^2}{2\chi}}, \chi = L_x/RT$$
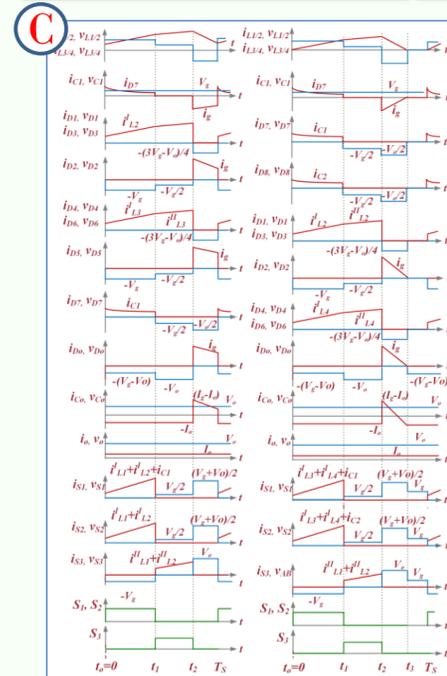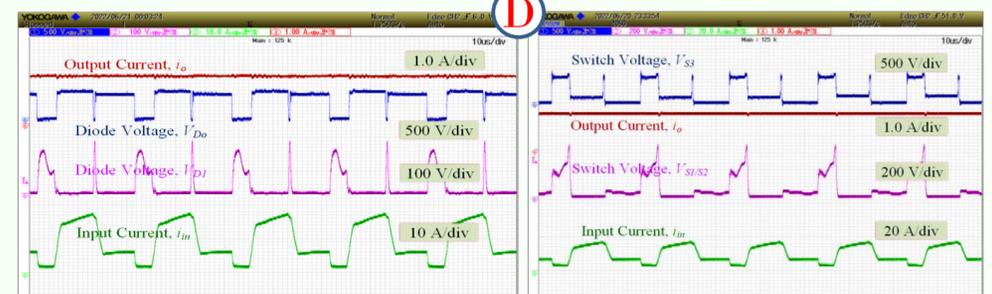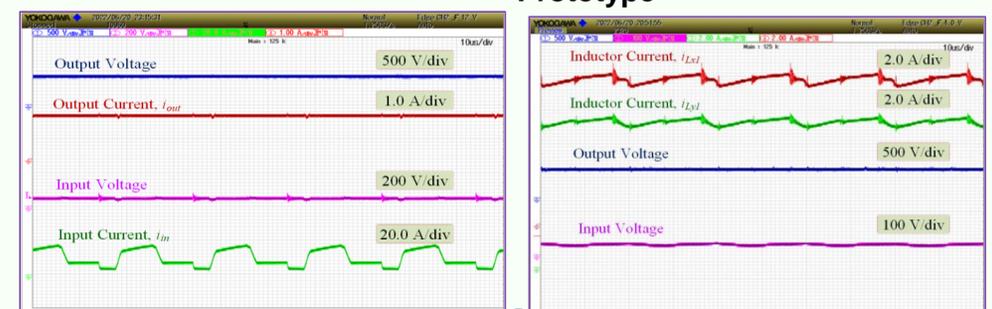
$$\eta = \frac{V_o/V_g}{(1 + 3k_1 + k_2)(1 - k_1 - k_2)^{-1} + 4\pi C_1 V_g^2 k_1 f + P_S}$$

Fig. 4. A. The voltage/current profile with same/different value inductors, B. The voltage gain plots, C. The characteristics plots of components, D. The Results for duty ratios of k_1=0.35, k_2=0.4