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SUMMARY

Adaptive Evolutionary Control for Complex Quadrotors Subject to 12-DOF Dynamic Uncertainties

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ABSTRACT

Quadrotor UAVs have attracted attention for their high maneuverability and vertical take-off and landing capabilities. However, controlling them remains challenging due to nonlinear dynamics, state coupling, actuator constraints, and sensitivity to parametric uncertainties and disturbances. Adaptive and nonlinear control techniques, especially backstepping-based methods, have proven effective in addressing these issues [1], [4].

How can trajectory tracking accuracy, robustness, and control efficiency of a nonlinear quadrotor UAV be improved under parametric uncertainties, external disturbances, and actuator constraints by integrating adaptive control and optimization techniques?

This work proposes an integrated control architecture combining Model Reference Adaptive Control (MRAC) and backstepping. MRAC compensates for parametric uncertainties by adjusting control laws in real time [2], while backstepping provides a recursive framework for stabilizing nonlinear quadrotor dynamics and handling state coupling [1]. A damping term is included to reduce control effort, and a genetic algorithm automatically tunes the control gains and adaptive parameters [3]. The controller is evaluated via simulations on a 12-degree-of-freedom quadrotor under time-varying uncertainties and external disturbances.

Simulation results show that the proposed control strategy improves trajectory tracking while reducing control effort compared to non-optimized or non-adaptive methods. The optimized controller maintains stability and accurate tracking despite parametric uncertainties and disturbances, consistent with recent adaptive and hybrid control studies[4].

The integration of MRAC and backstepping combines real-time adaptation to uncertainties [2] with robust stabilization of nonlinear systems [1]. Genetic algorithm tuning reduces manual parameter adjustment and enhances overall robustness [3]. Compared to advanced methods like feedback linearization and model predictive control [5], the approach balances implementation complexity and robustness.

This study presents an optimized and robust control framework for nonlinear quadrotor UAVs by integrating MRAC, backstepping control, and genetic algorithm-based parameter tuning. The results confirm improved trajectory tracking, reduced control effort, and enhanced robustness against uncertainties and disturbances. Future work will focus on real-time implementation and extension to cooperative multi-UAV systems operating under communication constraints and complex environments [4] .

***Keywords*—Nonlinear Control, AG Optimization, MRAC-Backstepping, Uncertain Quadrotor Dynamics**

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Robust tracking control of wheeled mobile robot subject to uncertainties

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ABSTRACT

This article introduces a robust tracking control method specifically designed for wheeled mobile robot (WMR), which tackles various sources of uncertainty such as wind disturbances and slipping. By applying the principles of the differential flatness methodology, the inherently under-actuated dynamics of WMR are transformed into a more manageable linear canonical form, facilitating the development of a stabilizing feedback controller. To effectively handle uncertainties arising from wheel slip and wind disturbances, the proposed feedback controller incorporates sliding mode control (SMC). However, the escalation of uncertainties may intensify chattering phenomena within the SMC framework, attributable to increased control inputs. To address this issue, a boundary layer surrounding the switching surface is introduced, implementing a continuous control law aimed at mitigating chattering effects. The stability properties of the closed-loop system are established using Lyapunov theory. Comprehensive numerical simulations are performed on a WMR system to evaluate the effectiveness and performance of the proposed control strategy.

Keywords—Differential flatness, Sliding mode control, Wheeled mobile robot.

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A Novel IoT Approach to Load Shedding for Real-Time Grid Stabilization

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ABSTRACT

Introduction

Electricity grids worldwide face significant challenges during peak demand periods, often resulting in outages and instability. Traditional load-shedding strategies, based on centralized control, are increasingly inadequate in the context of growing electrification and renewable energy integration. This paper introduces an Internet of Things (IoT)-based architecture for adaptive load management, aiming to enhance grid resilience and energy efficiency through real-time monitoring and decentralized decision-making.

Research Question

How can an IoT-driven system dynamically manage residential electricity consumption to reduce peak demand without compromising user comfort, while ensuring resilience to connectivity issues and scalability for future smart grid deployments?

Methodology

The proposed solution combines smart meters, connected sockets, and a mobile application, leveraging ESP32 microcontrollers, PZEM-004T sensors, and GSM modules for communication. Local exchanges use ESP-NOW for low-latency performance, while Firebase supports remote data aggregation. The system employs a deterministic rule-based decision engine, complemented by lightweight machine learning for prioritizing non-critical loads. Experimental validation was conducted on a prototype deployed in residential environments, measuring consumption patterns, load-shedding efficiency, and user interaction. Security measures include encryption, secure boots, and integrity checks.

Results

Tests demonstrated a substantial reduction in peak demand with minimal disruption to critical loads. Key performance indicators included percentage reduction in peak consumption, average downtime, and system availability. The architecture proved resilient under intermittent connectivity and maintained user-centric Quality of Service (QoS). Qualitative feedback indicated high user acceptance, particularly due to manual override options and real-time alerts.

Discussion

The findings highlight the trade-off between reducing load shedding and maintaining user comfort. Unlike centralized or cloud-based approaches, the IoT solution minimizes latency and ensures local decision-making, making it suitable for regions with unreliable connectivity. However, limitations include hardware dependency, variability in user behavior, and the need for continuous security updates. Economic considerations suggest that initial deployment costs may hinder large-scale adoption in low-income areas.

Conclusion

This research presents a modular, cost-effective IoT framework for dynamic load management, offering improved grid stability and energy efficiency. Future work will focus on integrating advanced predictive algorithms, diversifying hardware for interoperability, and enhancing cybersecurity through blockchain-based audit trails. Scalability studies will explore adaptation to urban and industrial environments, including hybrid renewable energy integration. Ultimately, the proposed system represents a promising step toward resilient, sustainable smart grids.

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***Keywords*— IoT-based Load Shedding; Smart Grids; Real-Time Monitoring; Demand Forecasting; Two-Way Communication.**

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A Comparative Study of Machine Learning Models for Fall Detection on the WEDA Dataset

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ABSTRACT

Falls are a leading cause of injury and the second most common cause of unintentional injury-related deaths worldwide, particularly among the elderly. They pose significant health risks and challenges for timely assistance. Effective fall detection systems are crucial for rapid intervention to reduce injury severity. However, achieving accurate and reliable detection remains challenging due to the variability in fall types and daily activities. This study focuses on developing a robust fall detection system using wrist-worn sensors from the WEDA fall dataset. We extract key statistical features such as minimum, maximum, mean, and variance to create a labeled dataset suitable for machine learning. We explored and applied several preprocessing techniques, including normalization, standardization, and a combination of both. For each preprocessing technique, we tested various machine learning algorithms while varying their hyperparameters to evaluate their performance in fall detection. These algorithms include k-nearest neighbors, support vector machines, decision trees, and random forests. Our results indicate that minimal preprocessing combined with key feature extraction yields high accuracy, ranging from 97% to 99%. This demonstrates that wrist-based data and selected algorithms can provide reliable fall detection and facilitate future hardware implementation for real-world use. In particular, the support vector machine with an RBF kernel and standardized data achieved the best results: 99.31% test accuracy, 97% cross-validation accuracy, and balanced sensitivity and specificity. These findings underscore the potential of wrist-worn sensor data and appropriate machine learning pipelines to address the critical need for effective fall detection in elderly care.

***Keywords*— Fall Detection, Sensor data processing, Machine Learning, SVM, KNN**

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Intelligent IoT-based monitoring system for biological sample management

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ABSTRACT

Introduction: Biobanks play an essential role in biomedical research by enabling the collection and preservation of biological samples [1], [2]. They provide researchers with valuable data, such as medical histories or genetic profiles, which are indispensable for personalized medicine [4]. Maintaining strict environmental conditions, particularly temperature, is vital to preserving the molecular integrity of biological resources.

Research Question: This study begins with the observation that traditional monitoring methods in biobanks rely primarily on manual measurements [20]. This approach exposes samples to late detection of thermal anomalies. The study seeks to answer: How can the management of storage conditions for biological samples in Senegalese biobanks, particularly temperature monitoring, be improved in order to reduce the risks of human error and storage anomalies?

Methodology: We designed our system using sensors connected to a microcontroller to continuously measure temperature and transmit the data to a local server via Wi-Fi. The data is also stored locally on an SD card to prevent loss in case of network failure. Data visualization is handled by the Node-RED platform, which displays the measured temperature in real time. Nodes are configured to send alerts to the biobank administrators if the critical threshold is exceeded.

Results: The developed system enabled continuous temperature monitoring of the biobank's various thermal chambers, with real-time data visualization and secure data recording. Tests conducted on three storage units (#07_CONG7, #06_CONG6, and #001GCBA) demonstrated the system's high reliability. The results indicate remarkable thermal stability, with a standard deviation of less than 0.5°C for most measurements.

Discussion: The use of IoT and visualization platforms such as Node-RED has transformed biobank management by improving the accuracy and speed of temperature control. Data analysis shows that the system not only allows for constant monitoring but also helps distinguish actual failures from instrumental anomalies. It meets international preservation standards, thus facilitating the integration of West African biobanks into global scientific networks [19].

Conclusion: This study demonstrated the effectiveness of a technological approach to ensuring the quality and integrity of bioresources, addressing the challenges posed by traditional monitoring methods. The results confirmed the thermal stability of the equipment and the effectiveness of the refrigeration system in maintaining the required storage conditions. Future directions include integrating LoRa technology for increased range and using artificial intelligence for predictive maintenance of storage equipment.

Keywords— Biobanking, IoT, Remote monitoring, Biological samples.

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