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ABSTRACT BOOK

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INVESTIGATION OF AUTONOMOUS ROUTE TRACKING PERFORMANCE IN UNMANNED SURFACE VEHICLES (USVS) THROUGH GPS INTEGRATION

Hakan TERZİOĞLU[1*], Beyza AKKOÇ[2]

Abstract – This study experimentally investigates the performance of GPS-assisted differential thrust control for autonomous route tracking in Unmanned Surface Vehicles (USVs). The system architecture consists of the Pixhawk Cube Orange+ for flight control tasks, the HERE4 GPS module providing high-precision positioning, and the NVIDIA Jetson Orin Nano, which handles AI-based decision-making processes. The control framework operates through a Python-based software communicating via MAVLink, processing real-time GPS data to determine the angular deviation between the vehicle's current heading and the target route. Based on this deviation, differential PWM commands are generated and transmitted to the thrusters through VESC 6.0 75A ESC drivers, enabling precise steering without the need for a rudder mechanism. Field tests demonstrated that the system maintained stable route-tracking performance despite environmental variability. The results indicate that integrating GPS-based localization with differential thrust control provides a reliable and effective autonomous navigation solution for USVs, even under challenging marine conditions.

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DETECTION AND CLASSIFICATION OF AERIAL TARGETS THROUGH THE FUSION OF COMPUTER VISION AND RADAR DATA

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Abstract – In this project, a decision-level fusion approach will be applied by combining radar and image data to ensure reliable detection and classification of mini and micro unmanned aerial vehicles (UAVs). The literature indicates that single-sensor systems suffer significant performance losses under conditions such as low visibility, interference, poor illumination, or small target size. Therefore, the project aims to integrate the range–velocity sensitivity of radar with the high recognition capability of deep learning–based image models (CNNs) through a software-based fusion algorithm, thereby developing a more stable, reliable, and environmentally robust classification system. In this way, the project seeks to contribute a domestic and modular approach to radar–image fusion studies, which are still limited in number and mostly originate from foreign sources. Within the proposed method, the MMAUD multimodal dataset developed by NTU ARIS will be used. Radar data (micro-Doppler signatures, range–velocity profiles) will be classified using machine-learning-based models, while image data will be classified with CNN-based deep learning architectures. After both models are trained independently, their probability outputs will be combined through decision-level fusion. Weighted averaging or Bayesian decision-combination methods will be used for the fusion step, enabling an adaptive decision mechanism based on the confidence scores of each sensor. The models will be evaluated using performance metrics such as accuracy, precision, recall, F1-score, and ROC-AUC, and results from single-sensor models will be compared with the fused model. Moreover, the system's stability under different weather and lighting conditions will be tested, and the impact of environmental variability on classification performance will be analyzed. The project management will proceed according to a six-phase schedule: literature review and feasibility analysis, data preprocessing, training of the image model, training of the radar model, implementation of decision-level fusion, and performance evaluation. All tasks are software-based and can be conducted using the existing laboratory infrastructure. The computational requirements of radar signal processing and CNN models will be met using Python, MATLAB, and deep learning libraries. The expected broader impact of the project includes developing a domestic approach in the field of multi-sensor classification, providing a sustainable and low-cost method for early detection of sUAV threats, and enabling the practical use of radar–image fusion in defense, security, and surveillance applications.

Keywords – Multisensor Fusion, Deep Learning–Based Classification, Micro-Doppler Analysis, Autonomous Detection Systems, Radar–Vision Integration

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ROBUSTNESS ANALYSİS OF DEEP LEARNİNG-BASED MİLİTARY AİRCRAFT CLASSİFİCATİON AGAİNST ADVERSARİAL ATTACKS

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Abstract- Real-time and high-accuracy identification of air platforms is a cornerstone of modern air defense and surveillance systems. However, the automatic recognition of military aircraft presents significant challenges due to their aerodynamic similarities, varying viewpoints, and complex environmental conditions. To address these challenges, this study proposes a deep learning-based classification framework utilizing the ResNet50V2 architecture initialized with transfer learning. The model was trained on a comprehensive dataset comprising 96 distinct military aircraft classes, employing extensive data augmentation strategies to enhance generalization. Beyond standard classification performance, a critical contribution of this work is the rigorous evaluation of the model's robustness against digital deception. The Fast Gradient Sign Method (FGSM) was applied to generate adversarial examples, simulating electronic warfare scenarios where imperceptible perturbations are introduced to deceive the AI. Experimental results demonstrate that while the proposed model achieves a classification accuracy of 75.52% on clean data, its performance degrades to 19.1% under FGSM attacks with an epsilon value of [0.03]. These findings highlight the vulnerability of high-performance deep neural networks to adversarial attacks and underscore the necessity of integrating robustness mechanisms into next-generation autonomous defense systems.

Keywords: Military Aircraft Classification, Deep Learning, Transfer Learning, Adversarial Attacks, FGSM, Defense Technologies.

VISUALIZING MODEL ATTENTION IN SAR-BASED MILITARY TARGET CLASSIFICATION

Utku Açış[1*], Havva Hazel ARAS[2]

Abstract: Synthetic Aperture Radar (SAR) is indispensable for modern Intelligence, Surveillance, and Reconnaissance (ISR) systems due to its capability to operate under all weather and lighting conditions. However, the inherent speckle noise and low resolution of SAR imagery pose significant challenges for Automatic Target Recognition (ATR). Furthermore, in critical defense applications, high classification accuracy alone is insufficient; the decision-making process must be transparent to ensure operational reliability. This study proposes a robust and explainable deep learning framework for classifying military ground targets using the MSTAR dataset. We employ the DenseNet121 architecture, utilizing its feature reuse mechanism to preserve critical signal details often lost in low-contrast radar images. To address the "black-box" nature of the model, we integrate Gradient-Weighted Class Activation Mapping (Grad-CAM). This technique visualizes the model's attention by computing the gradients of the target class score with respect to the final convolutional layer feature maps. The resulting heatmaps are overlaid on original images and presented in a Heads-Up Display (HUD) format to simulate operator situational awareness. Experimental results demonstrate that the proposed model achieves a classification accuracy of 95.42%. Qualitative analysis via Grad-CAM confirms that the network focuses on structural target features rather than background clutter, validating the system's reliability for radar-based threat detection.

PERFORMANCE BENCHMARKING OF PID, SMC, AND STSMC ALGORITHMS FOR WEAPON STABILIZATION SYSTEMS: A ROBUSTNESS AND PRECISION ANALYSIS

Serkan BUDAK[1*], Cemil SUNGUR[2], Akif DURDU[3]

Abstract – In modern defense applications, the operational efficacy of weapon turret systems is heavily contingent upon their ability to maintain precise pointing accuracy and rapid tracking performance amidst severe nonlinearities and external disturbances. Factors such as recoil forces, nonlinear friction, and platform vibrations pose significant challenges to conventional control strategies. This study presents a comprehensive comparative analysis of three distinct control architectures: the classical Proportional-Integral-Derivative (PID) controller, the Sliding Mode Control (SMC), and the Super-Twisting Sliding Mode Control (STSMC), applied to a two-degree-of-freedom (2-DOF) weapon stabilization platform. While the PID controller is favored for its structural simplicity, simulations indicate its limitations in suppressing varying disturbances and ensuring robustness against model uncertainties. Conversely, the conventional SMC provides superior insensitivity to parameter variations; however, it suffers from the inherent "chattering" phenomenon, which induces high-frequency oscillations detrimental to mechanical actuators. To address these deficiencies, the STSMC algorithm is implemented as a continuous second-order sliding mode approach. This method effectively mitigates chattering by integrating the high-frequency switching terms while preserving finite-time convergence characteristics. Comparative simulation results demonstrate that the STSMC strategy yields a superior dynamic response, achieving a reduction in settling time compared to PID and eliminating the chattering effect observed in standard SMC. Furthermore, under simulated scenarios involving wind gusts and recoil dynamics, the STSMC exhibits the highest tracking precision and disturbance rejection capability. These findings suggest that the Super-Twisting algorithm offers a viable and robust solution for next-generation high-precision fire control systems.

Keywords – Weapon Stabilization; PID Control; Sliding Mode Control (SMC); Super-Twisting Sliding Mode Control (STSMC); Chattering Alleviation; Robust Tracking.

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ARTIFICIAL INTELLIGENCE–BASED DATA COMPRESSION IN EDGE COMPUTING ENVIRONMENTS: A CONCEPTUAL DESIGN

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***Abstract** –* This study addresses the efficient processing of high-volume image, video, and time-series data generated by sensors, smart devices, and embedded systems in edge computing environments through artificial intelligence–based compression algorithms. The increasing data volume, bandwidth constraints, latency requirements, and energy consumption indicate that classical lossy and lossless compression methods are not sufficient for every scenario in modern applications. In recent years, deep learning–based autoencoders, asymmetric encoder–decoder architectures, attention mechanisms, and task-oriented compression approaches have enabled both higher compression ratios and the preservation of application-specific critical information. In this study, AI-based ossy and lossless compression approaches are examined within the context of edge–fog–cloud architectures, and a holistic framework that jointly considers data and model compression is presented. Recent studies published in the last five years are systematically reviewed, and their common trends and limitations are discussed. Furthermore, considering the limited memory, computational power, and energy resources of edge devices, a conceptual AI-based compression system is proposed that incorporates data-type awareness and error-bounded hybrid channels. This work does not present an experimental implementation; rather, it constitutes a literature-based investigation and system design, providing a foundational framework for future applied studies.

Keywords – Artificial Intelligence–Based Compression; Edge Computing; Data Compression; Model Compression; Task-Aware Compression

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MODELING AND ANALYSIS OF THE EFFECT OF FMCW RADAR WAVEFORM PARAMETERS ON PERFORMANCE

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Abstract – Radar (Radio Detection and Ranging) is a critical sensor technology that uses radio waves to detect the range, velocity, and direction of targets. Frequency Modulated Continuous Wave (FMCW) radars, an advanced type of this technology, measure range and velocity by analyzing the frequency difference between the transmitted chirp signal and the signal reflected from the target. FMCW is of critical importance for autonomous systems and the detection of UAVs (Drones). However, the performance of these systems depends directly on complex trade-offs created by parameters such as bandwidth and ramp time. Existing professional simulation tools generally present the signal processing chain as a black-box; this situation not only makes the optimization of system parameters difficult but also creates a conceptual barrier for researchers. This study presents a digital FMCW waveform and signal processing model designed with a white-box philosophy in the MATLAB/Simulink environment, aiming to overcome this barrier and pave the way for FPGA-based real-time applications. Within the scope of the project, signal generation (chirp), target modeling, mixer, filtering, and 1st FFT (Range) stages have been modeled step-by-step using basic mathematical blocks instead of ready-made libraries. As a result of the study, the effects of bandwidth and Doppler frequency variations on the beat frequency were tested in the simulation environment; the consistency between theoretical calculations and simulation outputs was demonstrated. This resulting structure serves as a tool that offers radar designers the opportunity to transparently observe the effect of parameters on the signal and enables the analysis of the system's responses to changing parameters prior to hardware (FPGA) implementation.

Keywords – FMCW Radar, Simulation, MATLAB, Parametric Analysis, Range Detection

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PID-BASED BALANCE AND MOTION CONTROL OF UNDERWATER VEHICLES

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Abstract- The ability of underwater autonomous vehicles (AUV) to move in a stable and precise manner depends on effective control of dynamics such as depth, orientation (yaw, pitch, roll) and speed. The underwater environment is a challenging structure in terms of control due to currents, lifting force changes and nonlinear hydrodynamic effects. In this study, the PID (Proportional, Integral, Derivative) control method, which is frequently used for the balancing and position control problems of underwater vehicles, is discussed. The presentation describes the basic operating principle of the PID controller. In terms of depth and orientation control, the error definition, feedback structure and the process of creating pusher (thruster) commands are detailed. Also, the sensor data (IMU, pressure sensor, etc.) integration into the PID cycle, the effects of delay and noise on system stability are examined. The effects of the different PID coefficients on the vehicle response were evaluated with experimental and simulation results, and common problems such as excessive oscillation, delayed response and instability were addressed. As a result, a properly adjusted PID control structure has been shown to provide a stable, reliable and repeatable motion control to underwater vehicles.

Keywords- thruster, AUV, IUM

DQN-BASED ADAPTIVE SCHEDULING UNDER MULTI-DIMENSIONAL NETWORK CONDITIONS

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Abstract – In modern communication and computing systems, the increasing user density, heterogeneous traffic patterns, and time-varying channel conditions have transformed the scheduling problem into a multi-dimensional and dynamic optimization process. In particular, the widespread adoption of delay-sensitive applications necessitates that resource allocation mechanisms prioritize service requirements (Quality of Service, QoS) rather than focusing solely on efficiency or fairness. In this context, traditional scheduling algorithms are insufficient to adapt to rapidly changing network conditions in real time. In this study, a Deep Reinforcement Learning (DRL)-based scheduling approach is proposed, which simultaneously considers traffic models, channel conditions, and service requirements. Within the proposed framework, a Deep Q-Network (DQN) agent with a discrete action space is designed and trained in a Python-based simulation environment. The simulation environment is modeled to incorporate time-varying traffic loads, stochastic channel gains, and flow-specific deadline constraints. At each time step, the agent observes the system state and allocates resources to an appropriate user, learning a policy aimed at minimizing deadline violations. The performance of the proposed DRL-based scheduler is evaluated in comparison with the Earliest Deadline First (EDF) and Weighted Fair Queueing (WFQ) algorithms. Experimental results demonstrate that, under the considered simulation scenario, the DQN-based scheduler reduces deadline violations by approximately 80% compared to classical methods. These findings indicate that the proposed approach provides a strong alternative for applications with strict delay sensitivity.

Keywords – Scheduling optimization; Deep reinforcement learning; DQN; QoS; Resource allocation

UNDERWATER ROCKET VEHICLE HYDRODYNAMIC DESIGN

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Abstract- In this project, the design and development of an Unmanned Underwater Rocket Vehicle (SARA) were carried out to investigate the feasibility and performance of underwater rocket systems. In recent years, underwater missions have gained significant attention in both academic and industrial fields, particularly in the development of autonomous systems capable of operating in complex aquatic environments. The SARA platform was designed as a prototype capable of entering the water in a controlled manner, performing assigned missions, and utilizing an original propulsion and guidance system. The system consists of two sealed compartments integrated into a single body. The front compartment houses the rocket and nose separation system, while the rear compartment contains the avionics system. A specially designed integration body connects the propulsion unit to the main body. Inside this structure, waterproof servo motors are placed, which are mechanically connected to the control fins responsible for the vehicle's steering and maneuverability. The primary goal of this project is to gain practical experience in the design, integration, and control of such systems, ultimately producing a functional prototype capable of stable underwater operation. The results obtained from this study are expected to contribute to future research in underwater propulsion technologies and guidance control systems.

Keywords – SARA

DEEP LEARNING BASED OBJECT DETECTION ON END DEVICES FOR THERMAL IMAGING DATA

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***Abstract*–** In this paper, thermal images and edge devices are discussed, and deep learning–based applications used on edge devices for thermal imagery are examined. First, thermal cameras and commonly used thermal datasets are introduced. Then, the architecture and limitations of edge devices, along with network pruning and quantization methods used for optimization on edge devices, are explained. Subsequently, machine learning software tools and hardware platforms employed in edge systems are reviewed. The advantages and disadvantages of edge devices are also discussed. In addition, a brief overview of deep learning is provided, and popular deep learning–based object detection algorithms such as YOLO and SSD are concisely explained. Finally, a literature review of studies on deep learning–based object detection on edge devices is presented.

Keywords – Deep Learning, Edge Devices, Object Detection, Thermal Cameras

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PERFORMANCE ANALYSIS OF ROS-BASED ROUTE PLANNING UNDER REALISTIC HYDRODYNAMIC CONDITIONS IN AUTONOMOUS UNDERWATER VEHICLES

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Abstract – This study addresses the path planning problem in autonomous underwater vehicles (AUVs) from a multidimensional perspective. The goal is to systematically evaluate the performance of different algorithm types under dynamic underwater conditions. Considering the expanding application areas of AUVs, energy constraints, and variable environmental dynamics, most existing studies remain limited to idealized models. These models do not adequately reflect realistic hydrodynamic conditions. Within this project, classical, machine learning–based, and hybrid path planning methods will be compared. These algorithms will be tested in a high-fidelity simulation environment based on ROS/Gazebo-uuv-simulator. The simulation will incorporate variable current profiles, sensor noise, and energy consumption into the model. In this way, the algorithms will be quantitatively evaluated in terms of robustness, computational efficiency, and path optimality. Ultimately, the study aims to contribute to the development of decision-support systems for autonomous underwater missions and to the integration of real-time path planning algorithms into physical AUV platforms.

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TARGET DETECTION FROM IMAGES

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Abstract – Object detection from images constitutes one of the fields of computer vision. As a result of the combination of computer vision and deep learning models, significant progress has been made in object detection processes. Deep learning is a machine learning algorithm consisting of many layers that predicts results with a given dataset. Today, it is used with different models in the field of object detection. The recognition of images has been enabled by the use of deep learning algorithms. It appears with high accuracy rates in object detection operations. It is observed that it comes to the forefront with the use of object detection in thermal cameras, unmanned aerial vehicles (UAVs), military vehicles, and autonomous vehicles. In this paper, studies related to target detection and recognition applications where object detection and deep learning methods are used together in the literature have been examined. Algorithms frequently used in object detection have been compared.

Keywords – Object Detection, Deep Learning, Computer Vision

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DEVICE PREDICTIVE MAINTENANCE BASED ON ARTIFICIAL INTELLIGENCE: A THEORETICAL AND SOFTWARE REVIEW

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Abstract – This study examines the theoretical and software-oriented aspects of artificial intelligence–based predictive maintenance systems, revealing how fault prediction and maintenance optimization are achieved in industrial processes. With the advancement of Industry 4.0, the use of IoT sensors, big data analytics, and machine learning models has become widespread in production lines, transforming maintenance strategies from reactive or periodic approaches into data-driven and predictive structures. In predictive maintenance systems, sensor data are collected in real time, processed through preprocessing stages, and then fed into machine learning and deep learning algorithms. The study evaluates the effectiveness of methods such as Random Forest, SVM, and LSTM in fault classification, anomaly detection, and Remaining Useful Life (RUL) prediction. Additionally, MQTT-based real-time monitoring, model performance metrics, and the integration of decision-support mechanisms into maintenance workflows are discussed. The findings show that AI-powered predictive maintenance reduces unplanned downtimes, enhances cost efficiency, improves operational safety, and extends equipment lifespan. The study also highlights that digital twin technologies, federated learning, and autonomous maintenance systems will play a critical role in future developments in this field.

APPLICATIONS AND FUTURE USES OF CARBON FIBER REINFORCED POLYMERS (CFRP) IN THE DEFENSE INDUSTRY

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Abstract – In today's defense systems, lightness, high mechanical strength, multifunctionality, and low radar visibility have become increasingly critical. In this article, carbon fiber-reinforced polymers (CFRP) stand out as advanced engineering materials of strategic importance due to both their structural efficiency and electromagnetic properties. This study examines forty-one sources published between 1999 and 2025 to comprehensively evaluate the current applications of CFRP in the defense industry and future trends. The literature shows that CFRP sinificantly reduces weight while increasing structural strength in aerospace platforms, efficiently dissipates impact energy in ballistic armor systems through multi-layered architectures, and enhances stealth capabilities through radar-absorbing structures and metamaterials. Furthermore, nano-additives, hybrid composite designs, metamaterial-based RAM solutions, and advanced manufacturing methods offer innovative research areas that will further expand the functional role of CFRP in future high-performance defense platforms.

Keywords – Carbon Fiber Reinforced Polymers (CFRP), Defense Applications, Ballistic Protection, Stealth Technology, Advanced Composite Materials

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IDENTIFICATION AND CLASSIFICATION OF AIR TARGETS BY COMBINING IMAGE PROCESSING AND RADAR DATA

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Abstract – Radar-camera fusion has become one of the fundamental building blocks of modern defense, aviation, and autonomous systems, particularly for critical tasks such as air target detection, tracking, and classification. By combining the radar's reliable range and speed measurement capabilities with the camera's high-resolution semantic perception, accuracy and stability that a single sensor cannot provide are achieved. This literature study comprehensively analyzes 30 different academic articles on radar-camera fusion, examining in detail each study's methodological approach, prominent models, data processing procedures, evaluation metrics, and results.The study also covers the working principles of radar and camera systems, data types, deep learning architectures used (Transformers, BEV models, knowledge distillation, Cross-Attention, Aggregation Transformers, multi-level fusion), fusion levels (early–mid–late), radar processing techniques (Doppler, Range-Azimuth, 4D Radar), camera-based 2D/3D detection methods, radar point cloud processing, BEV projection mechanisms, and modern metrics (mAP, NDS, RMSE, BEV AP) are explained in detail. This study compares radar-camera fusion methods presented in modern literature, identifies their strengths and limitations, and highlights the most effective solutions for air target detection. The strong performance of radar-camera fusion, particularly in low visibility, fog, rain, and night conditions, is emphasized; the critical role of fusion in air defense systems is discussed.This literature review serves as a comprehensive reference source for researchers working on radar-camera fusion, defense industry engineers, autonomous system developers, and academics.

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A THEORETICAL STUDY ON COMPOSITE FIBER PRODUCTION USING RPET

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Abstract – This study focuses on transforming polyethylene terephthalate (PET) waste—one of the major contributors to environmental pollution—into a valuable resource through advanced recycling techniques. In the project, recycled PET will first be chemically modified via sulfonation using sulfuric acid, after which the obtained intermediate material will be processed into carbon-fiber-like composite fibers through electrospinning. The approach aims to both reduce the ecological impact of plastic waste and propose a more sustainable production route compared to the energy-intensive and expensive methods used in traditional carbon fiber fabrication. The mechanical, thermal, and structural characteristics of the produced fibers will be examined using analytical tools such as FTIR, TGA/DSC, SEM, and XRD. Ultimately, the project is expected to improve the usability of waste PET in engineering applications, support environmental sustainability, and present an innovative pathway for material development. In addition, the resulting fibers are envisioned to provide a domestic and cost-effective alternative for high-tech fields, including defense, automotive, aerospace, and construction industries.

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ARTIFICIAL INTELLIGENCE SUPPORT IN FIREFIGHTING: A THEORETICAL AND SOFTWARE REVIEW

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Abstract – This study examines the contributions of artificial intelligence technologies to fire management from both theoretical and software-oriented perspectives. Early fire detection, risk analysis, and spread prediction can be significantly enhanced through big data, image processing, sensor networks, and machine learning techniques. The study provides a detailed evaluation of the role of machine learning, deep learning (CNN, LSTM), computer vision, and IoT-based systems in fire management. Using Python, TensorFlow, OpenCV, and Scikit-learn libraries, example applications related to image classification, sensor data analysis, risk prediction, and real-time alert systems are presented. The findings indicate that AI-based models offer faster, more accurate, and more scalable solutions compared to traditional methods. Early warning mechanisms reduce loss of life and property, while spread prediction models enable more effective operational decision-making. However, challenges such as data quality, real-time processing constraints, and system security directly influence the success of AI applications. In conclusion, AI-supported fire management represents a critical innovation for reducing disaster risks and optimizing intervention processes. The development of new models, sensor technologies, and drone-based systems is expected to provide significant opportunities in fire management in the future.

Keyword - Fire Detection with Artificial Intelligence; Fire Risk Analysis; Early Warning System; Drone-Based Monitoring; Fire Managemen

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GPS-INDEPENDENT AUTONOMOUS NAVIGATION STRATEGIES IN THE BATTLEFIELD: COMPARATIVE ANALYSIS OF VISUAL ODOMETRY AND SLAM ALGORITHMS

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Abstract – Although Unmanned Aerial Vehicles (UAVs) and autonomous systems provide operational superiority in the modern battlefield, high dependence on Global Navigation Satellite Systems (GNSS/GPS) constitutes a serious strategic vulnerability. Today, developing electronic warfare technologies can easily disable satellite-based navigation systems through jamming and spoofing methods. This situation has necessitated the development of autonomous systems capable of operating in "GPS-denied" environments. In this study, a comprehensive literature review is presented on current methods used for autonomous platforms to determine their position and generate routes in environments where GNSS signals are inaccessible. Within the scope of the study, Simultaneous Localization and Mapping (SLAM) algorithms, camera-based Visual Odometry techniques, and LiDAR-supported mapping methods are examined. Algorithms in the current literature (ORB-SLAM, LOAM, VINS, etc.) are analyzed comparatively in terms of processing load, real-time operating capacity, robustness to environmental factors, and accuracy rates. Furthermore, the role of sensor fusion methods, where inertial sensors (IMU) and image data are combined, in minimizing drift errors is discussed. In conclusion, it is evaluated that the sensor-based autonomous navigation capability, which eliminates satellite dependency, will be the most resilient strategic element against electronic warfare in future warfare doctrines.

Keywords – GPS-Denied Navigation, SLAM, Visual Odometry, Electronic Warfare, Autonomous Systems, Sensor Fusion.

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ARTIFICIAL INTELLIGENCE BASED THREAT DETECTION AND AVOIDANCE SYSTEMS IN AUTONOMOUS UNMANNED AERIAL VEHICLES (UAV)

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Abstract – This study presents a comprehensive literature review of 30 academic articles on threat detection, avoidance, autonomous planning, deep reinforcement learning (DRL), multi-agent reinforcement learning (MARL), communication security, and intelligent transportation systems (ITS). The review covers a wide range of technologies, from image processing-based obstacle detection to deep learning-supported route planning, from swarm coordination to communication attacks. The majority of the methods proposed in the papers are based on DRL, GNN, MARL, hierarchical learning, explainable artificial intelligence (XAI), robust decision-making, real-time planning, potential fields, and autonomous control architectures. The study shows that threat detection and avoidance systems have aggressively shifted towards DRL-based algorithms in recent years. At the same time, MARL-based approaches have become dominant in swarm communication and cooperation. However, security threats such as adversarial attacks, communication manipulation, and sensor errors have been identified as the weakest points of these systems. The study concludes by presenting future trends, challenges, and potential research opportunities for UAV-based systems.

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MANAGEMENT OF UNMANNED SEA VEHICLE AVIONIC COMPONENTS WITH A DOMESTIC POWER DISTRIBUTION CARD

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Abstract - This study presents the design and implementation of a unique Power Distribution Board (PDB) for use in Unmanned Surface Vehicle (USV) projects. The designed system aims to meet the stable energy requirements of critical avionics components such as the high-processing-power Jetson Orin NX artificial intelligence computer and the Pixhawk Cube Orange autonomous controller. Voltage drops, signal noise, and sensor failures caused by existing ready-made solutions and scattered cabling structures threaten system reliability. To eliminate these problems, a domestically developed board was created that optimizes and distributes the high energy from the 6S8P LiPo battery pack, prevents cable clutter, and considers electromagnetic compatibility (EMC). The resulting design, using innovative integrated circuits and efficient power topologies, has increased the stability of the avionics system and centralized energy management.

*Keywords-*Unmanned Surface Vehicle, Power Distribution Board, Jetson Orin NX, Pixhawk Cube Orange, Power Electronics, PCB Design

COMPARISON OF STABILITY GUARANTEES IN LYAPUNOV-BASED ADAPTIVE AUDITS

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Abstract- The four adaptive modality methods Model Reference Adaptive Control (MRAC), L1-Adaptive Control, Gain-Scheduling Control, and Model-Free Adaptive Control (MFAC) aim to compare Lyapunov-based stability analyses. The MRAC method is a classic adaptive control strategy that drives system performance through the reference model. L1-Adaptive Control is a modern approach that aims to suppress control signal fluctuations along with fast parameter adaptation. Gain-Scheduling method provides an effective solution in non-linear systems with the application of different control gains according to the working points. Model-Free Adaptive Control provides a data-driven control framework where the system model is not clearly known.

Within the scope of the study, the control law and adaptation mechanism of each method are analyzed within the framework of Lyapunov theory; stability conditions, parameter convergence characteristics and error dynamics are examined mathematically. In addition, the advantages and limitations of each method will be supported by numerical simulation results and a comparative evaluation will be presented. As a result of these analyzes, it will be discussed which adaptive audit approach is more appropriate for different types of systems and levels of uncertainty.

A HYBRİD APPROACH FOR COGNİTİVE SECURİTY: DEEPFAKE DETECTİON WİTH SEMANTİC CONSİSTENCY AND BİOLOGİCAL SİGN

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Abstract – Powered by Productive Contentious Networks (GAN) and Diffusion Models, DeepFake technology poses a significant threat to information integrity and national security. Traditional pixel-based detection methods fall short in the face of high-quality synthetic media. This study proposes a unique "Multi-Layer Semantic Verification Network (MSVN)" architecture that moves the detection paradigm from "artifact hunting" to "meaningful consistency control". The proposed method integrates Bidirectional Self-Abspection Learning (PCL) and Remote Photopletismography (rPPG) techniques that analyze biological heartbeat signals to detect source property discrepancies. Theoretical analyses and literature review suggest that this hybrid approach could provide superior detection accuracy to individual systems, particularly against unprecedented production methods. Keywords: DeepFake Detection, Cognitive Safety, rPPG, Semantic Consistency, Artificial Intelligence Forensic Computing.

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FIELD SCANNING AND THREAT DETECTION WITH AUTONOMOUS DETECTION ROBOT

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Abstract – This study examines the role of autonomous systems in field scanning and threat detection tasks, which have gained importance with the rapidly developing technologies in the defense industry. Unmanned Ground Vehicles (UGVs) and Unmanned Aerial Vehicles (UAVs) can reliably and effectively perform complex tasks without human intervention thanks to the integration of artificial intelligence and robotic systems. The study examines the system architecture of autonomous military robots, fundamental sensor technologies used in environmental perception (LiDAR, RADAR, GNSS/IMU), critical threat types such as mines (EO/UXO) and CBRN elements, and commonly used artificial intelligence-based methods (YOLOv8, deep reinforcement learning) for detecting these threats. In addition, modern navigation and motion planning algorithms (A*, RRT, DWA) that enable robots to move independently, as well as UAV–UGV collaboration approaches and cyber-physical security components, are also evaluated. The findings indicate that autonomous systems have become a critical component of future defense doctrines.

Keywords – Autonomous Detection Robot; Multi-Sensor Fusion; Threat Detection; SLAM; LiDAR (Laser Scanning Sensor); EO/IR Camera; Radar Sensor, GNSS/IMU; Autonomous Navigation; Field Scanning

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ELECTRICAL DRIVE AND SOFTWARE INTEGRATION IN AUTONOMOUS VEHICLES: ENERGY MANAGEMENT, HIGH-POWERED SENSORS AND COMMAND-CONTROL SYSTEMS

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Abstract – This study aims to examine how the architecture of energy management systems can be presented through a decision support process in the context of hybrid electric propulsion, high-power sensors, and integrated command, control, communications, intelligence, surveillance, and reconnaissance (C4ISR/C2) systems. From a technical perspective, the research addresses the integration of electric propulsion systems and software infrastructures for self-propelled and semi-self-propelled military ground platforms. The research findings indicate that electric propulsion systems offer advantages such as high efficiency, silent operation, and onboard backup power; however, they also face limitations related to battery energy density and charging infrastructure. Vehicle examples including FNSS KAPLAN HYBRID, RHEINMETALL, MISSION MASTER, and MILREM THEMIS were examined, and system block diagrams, control algorithms, and architectural designs were evaluated using literature review and platform model analysis, after which the details are presented comprehensively. With respect to this integration, engineering requirements were identified in areas such as data-intensive communications, power management, and algorithmic complexity. Research and development topics related to the future of advanced batteries, fuel cells, and increased autonomy technologies were also addressed. From a software perspective, open architectures such as NGVA, VICTORY, and FACE/SOSA, together with artificial intelligence–assisted decision-making units, can enable the effective utilization of sensor data and the transformation of combat information into enhanced situational awareness.

Keywords – Autonomous ground platforms, electric propulsion systems, command and control (C4ISR), artificial intelligence, energy management, sensor fusion.

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ADAPTIVE PID THREAD FOR MODEL UNCERTAINTIES IN FLIGHT DYNAMICS: SELF-ADJUSTING PID CONTROLLER DESIGN FOR UAV UNDER OUTSIDE WINDBREAKERS

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Abstract- Unmanned aerial vehicles (UAVs) have rapidly expanded in civilian and military applications in recent years. The ability of unmanned aerial vehicles to perform safe and precise flight is directly related to the accuracy and stability of control systems. However, real flight environments often contain uncertainties and external disruptors; for example, wind, thermal currents or sudden load changes can negatively affect UAV performance. Therefore, classic PID controllers may not be able to perform adequately in the face of such uncertainties when working with fixed earnings. Adaptive PID control is a method developed to overcome these limitations. In adaptive approaches, PID gains are updated online based on system behavior, resulting in more robust control against external disruptors with parameter uncertainties. Fuzzy gain-tuning and MRAC-based PID methods, in particular, are widely used to implement such adaptation mechanisms in UAVs. Fuzzy-based methods simulate human logic and adjust PID gains based on error and error change, while MRAC (Model Reference Adaptive Control) based methods track system behavior according to the reference model and adapt the earnings. The aim of this study is to examine the adaptive PID controller design for UAV under external wind disruptors and model uncertainties, and to compare the performance of Fuzzy gain-tuning and MRAC-based PID. Simulation studies will simulate wind effects and system parameter changes, demonstrating the effects of both methods on flight accuracy, tracking ability and control signal stability. Furthermore, the results obtained will provide a basis for assessing the applicability and effectiveness of adaptive control methods in future UAV control strategies.

INDUSTRIAL ENERGY EFFICIENCY AND WASTE HEAT RECOVERY

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Abstract- The industrial sector represents one of the most energy-intensive areas globally. In this regard, examining energy-use patterns in industry is crucial for mitigating global warming and reducing greenhouse gas emissions. Approximately 38% of global final energy consumption occurs in the industrial sector; therefore, minimizing energy use in industrial processes is essential (Brueckner et al., 2014). In recent years, driven by international efforts and regulatory measures aimed at curbing greenhouse gas emissions, reducing industrial energy consumption has become a key priority. Moreover, improvements in energy efficiency are known to yield lower operational costs and enhanced profitability (Varga and Palotai, 2017). Nevertheless, even in facilities where thermal systems have been optimized, a significant amount of high-temperature waste heat is still discharged into the environment. To address this, various approaches exist for waste-heat recovery, including direct utilization or the application of exhaust-heat technologies to generate heat or electricity (Brueckner et al., 2014).

ENERGY MANAGEMENT AND CONTROL ALGORITHMS IN HYBRID AND FULL-ELECTRIC CRAWLER ARMOURED VEHICLES

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Abstract – A series hybrid architecture, as observed in previous studies on the FNSS KAPLAN HYBRID, requires the management of multiple resources such as power distribution, batteries, and traction motors. However, this research focuses on power management and control algorithms for hybrid armored vehicles and fully electric tracked vehicles. The powertrain, including a diesel generator, battery pack, and propulsion system, was modeled using Simulink/Matlab-based simulation software, and different power management strategies were evaluated [1][2]. As an applied case study, the FNSS Kaplan Hybrid vehicle was considered; features such as silent mode operation, regenerative braking, and external power export were analyzed for this platform equipped with a 56 kWh lithium-ion battery, two 230 kW electric motors, and a 300 kW diesel generator [3][4]. The results indicate that advanced energy management algorithms can significantly reduce fuel consumption (e.g., Randive et al. reported a 30% improvement [5], while many studies have shown that reinforcement learning (RL)–based strategies achieve savings between 5% and 25% [6][7]). In addition, fuel savings of up to 5% are targeted for the Kaplan Hybrid prototype [8].

Keywords – Hybrid electric vehicles, fully electric vehicles, energy management, battery management, control algorithms, model predictive control (MPC).

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HYBRID ROUTE PLANNING IN A2/AD ENVIRONMENTS FOR MILITARY UAVS: INTEGRATION OF ANTS COLONY AND DEEP REINFORCED LEARNING

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Abstract –Especially mission-critical autonomous systems such as Unmanned Aerial Vehicles (UAVs) face complex challenges in Anti-Access/Area Denial (A2/AD) environments, where GPS is denied and threats are dynamic. This paper presents a Dynamic Risk-Aware Planner (DRP) that combines Ant Colony Optimization (ACO) for global path planning with Double Deep Q-Networks (DDQN) for local reactive maneuvering. The proposed algorithm optimizes a multi-objective cost function that incorporates Radar Cross-Section (RCS) exposure, fuel consumption, and terrain masking. Theoretical evaluations indicate that this hybrid approach significantly enhances survivability compared to traditional A* or Dijkstra algorithms.

Keywords – ACO, Deep Reinforcement Learning, Military Logistics, Stealth Navigation,UAV Route Plannig

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ARTIFICIAL INTELLIGENCE–BASED DRIVER DROWSINESS DETECTION IN MILITARY GROUND VEHICLES

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Abstract One of the major causes of accidents in both civilian transportation and operational missions is the loss of driver attention due to fatigue and drowsiness. This issue poses significant risks not only in civilian environments but also in military ground vehicles, where mission success and personnel safety are critical. Long-duration patrols, challenging terrain, night operations, and operational stress increase the likelihood of decreased attention among military personnel, threatening vehicle safety, crew security, and mission integrity. This project aims to enhance operational safety by monitoring driver behavior in military ground vehicles in real time, detecting early signs of fatigue, and delivering timely warnings. The system combines YOLOv8-based image processing, OpenCV face–eye tracking, and LSTM   (Long Short-Term Memory)–based time-series analysis to evaluate key behavioral signals related to driver alertness. While YOLOv8 detects immediate visual indicators such as eye closure duration, yawning, and head movements, the LSTM model analyzes temporal patterns of these behaviors to predict fatigue tendencies with greater stability and accuracy. This hybrid approach provides improved robustness again"st environmental challenges common in military operations, such as poor lighting, vehicle vibration, and extended mission durations.

When a   risk is detected, the system alerts the driver through auditory (buzzer) and visual (LED) notifications, helping maintain situational awareness during operations. The use of   a   Raspberry   Pi platform ensures low power consumption, portability, and adaptability, making it suitable for seamless integration into various military ground vehicles.

This study presents an important solution for monitoring driver alertness, preventing operational errors, and enhancing both personnel and vehicle safety in military missions. The system functions not only as a warning mechanism but also as a critical support technology that improves safety and effectiveness in military operations. In the long term, such systems can contribute significantly to developing a safer, more conscious, and more controlled driving culture within military environments.

Keywords – Autonomous Systems, Defense Technologies, Driver Drowsiness Detection, Driver Monitoring, Machine Learning

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METHODOLOGY OF APPLICATION OF ELECTRIC AND HYDROGEN FUEL HYBRID ENERGY STORAGE SYSTEMS IN MILITARY VEHICLES USED IN LAND, AIR AND SEA FORCES

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Abstract- Today, the world is facing serious crises such as climate change and air pollution. A long-term solution to these problems requires massive electrification of energy and the provision of that electricity from clean, renewable sources. While there are electric alternatives available for many energy sectors, the same is not the case for long-haul and heavy-duty passenger aircraft, freight trains or ships. Net solutions have not yet been developed, especially in military combat vehicles such as armored tanks, ocean vessels and both rotary and fixed-wing aircraft. Some argue that such means of transport are not suitable for electrification. In contrast, hybrid electric vehicles are gaining more and more attention in both civilian and military areas, thanks to their better fuel economy and lower emissions advantages than conventional internal combustion engines. However, it should be noted that vehicle electrification has different requirements and priorities than civilian use in army applications. This study examines the potential of land, air and marine vehicles to be converted into battery electric or hydrogen fuel cell equivalents, taking into account a wide range of parameters such as range, mass, volume and power-to-weight ratio. At the same time, the benefits that can be provided by electric vehicles with increased range are evaluated. Features such as fuel economy, quiet operation, maneuvering, climbing capabilities and thermal signatures of vehicles; load carrying capacity, type of duty, operating conditions and depending on the optimization of drive systems are emphasized. In this context, it is revealed that armored tanks, freight trains, boats, ocean vessels, helicopters, propeller planes and jumbo jets have the potential to be converted into electrification in line with the technologies and workable solutions proposed in the existing literature.

CONCEPTUAL DESIGN AND ANALYSIS OF A RENEWABLE ENERGY-POWERED UNMANNED AERIAL VEHICLE SYSTEM

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Abstract – Drone usage is rapidly increasing in many different fields due to technological developments. Although they have their own specific areas of use, their flight times are also becoming increasingly important. In this study, a drone system was designed and analyzed. It is a modular unmanned aerial vehicle (UAV) that can charge itself using renewable energy sources. The drone is hexagonal in shape, and carbon fiber and fiberglass-based materials were chosen for its structure to ensure lightness and high strength. The unique aspect of the system is that the batteries can be charged using renewable energy sources thanks to integrated wind turbines that can utilize the airflow generated by the motors during flight and the environmental wind, as well as photovoltaic (PV) panels placed on a large surface area. This aims to extend flight time, increase mission continuity, and reduce external energy dependence. Static analyses performed on the structural components using SolidWorks software demonstrate that the design is mechanically robust. In conclusion, this study presents an innovative and feasible design for renewable energy-powered, scalable UAV systems with high mission continuity.

Keywords – Renewable energy, Unmanned aerial vehicle, Drone, Design, Analysis

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DEFECT FORMATION MECHANISMS IN THE SELECTIVE LASER MELTING PROCESS OF METALS: A COMPREHENSIVE REVIEW

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Abstract – Selective Laser Melting (SLM) is one of the most advanced additive manufacturing technologies, enabling the high-precision production of metal materials with complex geometries. However, high energy densities, sudden temperature gradients, and rapid solidification rates lead to the formation of a wide variety of metallurgical defects, such as lack of fusion, keyhole porosity, gas entrapment, hot tearing cracks, and grain orientation. In this review study, the defect types in the SLM process and the formation mechanisms of these defects were comprehensively examined based on experimental, theoretical, and numerical studies in the literature. Within the scope of the study, the interactions between process parameters, melt pool dynamics, powder morphology, thermal cycles, and microstructure evolution were evaluated, and the process structure property relationship was presented within a holistic framework. The results show that defect formation is not dependent on a single parameter but is determined by the simultaneous effects of energy density, scanning strategy, cooling rate, powder quality, and laser material interaction. In this context, the study aims to contribute to the understanding of fundamental metallurgical mechanisms for making SLM processes more stable, reliable, and predictable.

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CRITICAL ANALYSIS OF DEEP LEARNING METHODS FOR THE DETECTION OF SMALL AND CHALLENGING UAVS IN THERMAL/IR IMAGERY

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Abstract – Recent military conflicts, particularly the Russia-Ukraine War, have highlighted the asymmetric warfare potential of small and kamikaze-class Unmanned Aerial Vehicles (UAVs) and the critical strain they place on conventional air defense systems. The detection of these targets, which have a low Radar Cross-Section (RCS), necessitates the use of Thermal/Infrared (IR) imaging systems that remain effective even in poor weather and low-light conditions. This study reviews current Deep Learning (DL) based methods for detecting small, low-visibility UAVs in thermal imagery. Existing approaches in the literature are critically analyzed, with a focus on how they tackle challenges such as the target's small thermal signature and low thermal contrast. The analysis examines the trade-off between real-time capability (FPS) and detection accuracy (mAP) to identify the most suitable DL model architectures for operationally viable systems. Despite the high performance reported in laboratory settings, we conclude that the reliability and speed of current methods must be enhanced for challenging real-world scenarios. Accordingly, we present a roadmap for our future work, which involves designing a high-speed detection algorithm optimized for small object detection and suitable for embedded systems. This review summarizes the current state of thermal UAV detection, establishing a critical foundation for future robust and integrated defense solutions.

Keywords – Thermal Imaging, Small UAV Detection, Deep Learning, Air Defense

MULTI COLOR TRACKING BY IMAGE PROCESSING AND 3-DIMENSIONAL DISTANCE CALCULATION METHOD FOR AUTONOMOUS PLATFORMSMULTIC COLOR TRACKING BY IMAGE PROCESSING AND 3-DIMENSIONAL DISTANCE CALCULATION METHOD FOR AUTONOMOUS PLATFORMS

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Abstract – This study aims to achieve high-accuracy object detection under varying lighting conditions for robotic and automation applications and to present an advanced color detection system capable of reliably estimating the distance to the object. The developed system uses adaptive HSV masks that are dynamically adjusted according to ambient brightness for color segmentation and successfully tracks selected colors such as Orange, Blue, and Red. The center point of the object within the camera frame (X, Y coordinates) is determined in real time. The most critical component of the system is its ability to calculate estimated distance based on the Pinhole Camera Model principle, which relies on the object's reference physical size and the camera's focal length parameters. This allows the distance to detected objects to be measured in centimeters, classifying objects into regional categories such as 'Very Close', 'Close', and 'Medium'. The study demonstrates that this adaptive approach, enhanced with morphological operations and similarity scoring mechanisms, is more robust and less sensitive to noise compared to standard color segmentation. By simultaneously providing both two-dimensional positional information and vital three-dimensional distance data for detected objects, the system establishes a critical infrastructure for safe navigation and precise object manipulation on autonomous mobile platforms.

Keywords – Image Processing, Color Detection, HSV Segmentation, Pinhole Camera Model

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IMU-BASED PID DEPTH CONTROL AND FLAP-CONTROLLED U-TURN ALGORITHM FOR UNDERWATER ROCKET

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Abstract – This study presents a control architecture designed to enable an autonomous underwater rocket to perform the tasks of moving along a linear path at a constant depth plane, executing a U-turn maneuver, and returning to the starting line. In the proposed structure, vertical axis movement is controlled by applying a classical PID controller to the error signal defined by the difference between the measurement obtained from a pressure-based depth sensor and the reference depth. The proportional, integral, and derivative components of the PID equation are adjusted to limit fluctuations, reduce steady-state error, and keep overshoot under control. The controller output is transmitted as an angle command to the servo motors driving the vehicle's hydrodynamic fins, achieving a stable depth profile around the target depth band. Within the scope of attitude control, the vehicle's yaw movement around its vertical axis is taken as the basis, and the targeted yaw angle for the U-turn maneuver is defined as the reference. During the maneuver, an asymmetric lift and drag distribution was created on the body by setting the upper and lower fins to a specific fixed angle; the vehicle's controlled rotation was achieved using these hydrodynamic moments. The yaw angle estimation was performed by integrating the angular velocity (gyroscope) data obtained from the inertial measurement unit (IMU) over time and using Pixhawk-based sensor fusion algorithms. The linear distance traveled during the mission was calculated approximately only through the numerical integration of acceleration data read from the IMU. The findings demonstrate that this control architecture, designed with a limited sensor suite and relatively low computational complexity, can provide repeatable, stable, and autonomous motion capability for underwater rockets.

Keywords – Underwater rocket; autonomous control algorithm; PID controller; depth control; yaw control; IMU; fin-based maneuver

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COMPARATIVE ANALYSIS OF ENERGY STORAGE UNITS AND INNOVATIVE APPROACHES FOR ELECTRIC MILITARY VEHICLES

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Abstract – Electricity, as it is in almost every area of daily life, is also an indispensable element for military operations. This intense need for energy has become a vital part of national security, especially in terms of military operations. In this context, the main focus of this article is to provide a comprehensive assessment by addressing energy storage and innovative approaches in military facilities. A large portion of the energy used today is supplied through outdated transmission and distribution infrastructure, which does not provide a sufficiently resilient structure for military operations in remote areas where access is difficult. Furthermore, electrical distribution networks are vulnerable to both physical and cyber attacks, which can cause disruptions in energy supply to strategic locations. To counter such threats, the armed forces of many countries are developing new projects focused on microgrid systems. These systems offer an independent and controllable structure that utilizes renewable energy sources, supported by electric vehicles, energy storage solutions, and modern control devices. However, to effectively utilize renewable energy sources, an energy storage infrastructure to support these sources is essential. In this regard, the article aims to examine in detail the application of energy storage technologies for the military sector and the impact of this technological advancement on military operations and routines.

FATIGUE DAMAGE MECHANISMS IN COMPOSITE MATERIALS: A COMPREHENSIVE REVIEW FROM THE PERSPECTIVE OF DEFENSE AND AEROSPACE APPLICATIONS

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Abstract – Composite materials have become essential structural components in modern defense and aerospace systems due to their high specific stiffness, superior strength to weight ratios and architectural tailorability. However, the inherent heterogeneity and anisotropy of fiber reinforced polymer composites lead to a multistage damage evolution that fundamentally differs from the classical crack driven fatigue behavior observed in metals. Matrix microcracking, interfacial debonding, fiber breakage and interlaminar delamination progress in an interactive manner, making fatigue one of the most critical yet least predictable failure modes in mission critical platforms such as unmanned aerial vehicles, missile bodies, hypersonic structures and composite pressure vessels. This review systematically examines the initiation conditions, energetic interactions and propagation characteristics of fundamental fatigue damage mechanisms in composite laminates. The influences of fiber architecture, matrix chemistry, environmental exposure, manufacturing induced defects and multiaxial loading on fatigue performance are synthesized through a comprehensive evaluation of five decades of research. Advanced characterization techniques including digital image correlation, acoustic emission monitoring, scanning electron microscopy and three dimensional X ray computed tomography are assessed for their capability to detect early stage internal damage and to support physics informed fatigue life prediction models. The overall assessment demonstrates that fatigue in composite structures must be regarded as a multiscale and multiphysics degradation process rather than a single failure mechanism in order to ensure structural integrity in defense and aerospace applications. This review provides an integrated framework that relates fatigue behavior in high performance composite structures to design requirements, environmental interactions and long term durability criteria.

*Keywords –*Fiber-reinforced composites, Fatigue damage evolution, Interfacial debonding and delamination, Defense and aerospace structures, Advanced damage monitoring techniques

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ARMED PİSTOL DRONE DESİGN

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Abstract - Unmanned Aerial Vehicle (UAV) technologies have experienced rapid development due to advances in electronic control systems, autonomous operation, and remote-control capabilities. The ease of manufacturing and deployment, vertical take-off and landing capability without runway requirements, compact structure, and payload flexibility have significantly increased the utilization of UAVs in civilian, defense, and security applications. Recent developments in software and hardware have enabled the emergence of armed drone systems designed for enhanced security and tactical operations. In this study, an armed UAV system with automatic firing stabilization is designed to operate effectively in both daytime and nighttime military and security missions. The system architecture is developed by integrating multidisciplinary hardware and software solutions within the scope of command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR), electro-optics, artificial intelligence, cybersecurity, and big data technologies. The proposed drone system is capable of performing simultaneous tasks, including target area detection, threat neutralization, post-operation damage assessment, and real-time image transmission. Additionally, the system can be utilized as an offensive platform when required. The armed drone is designed with an effective operational range of 40 m and a firing range of up to 150 m, and it is capable of carrying 8 or 16 rounds of 5.56×45 mm NATO ammunition. To enhance firing accuracy and recoil damping, the weapon system is configured to operate at a 90-degree downward firing angle. The entire system is controlled via a ground control station. The proposed UAV model serves as a survivability enhancer against hostile fire and ambush threats and provides an effective aerial fire support solution for personnel, vehicles, and convoy protection.

DETECTION AND FEATURE-BASED CLASSIFICATION OF MARITIME VESSELS USING DEEP LEARNING WITH IMAGERY COLLECTED FROM UNMANNED AERIAL AND SURFACE VEHICLES

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Abstract – This research aims to develop an integrated deep learning approach that addresses the critical problem of detecting and classifying maritime vessels for marine security by combining overhead images obtained from Unmanned Aerial Vehicles (UAVs) and side-view images collected from Unmanned Surface Vehicles (USVs). In the literature, the need for optical image–based methods has been increasing, particularly for detecting targets such as dark ships that turn off AIS data or broadcast falsified information. The reliance on single-source image models, limited architectural diversity, challenges in small-object detection, and the lack of feature optimization are considered major gaps in existing studies. This work aims to overcome these limitations and present a more robust, generalizable, and multi-source classification framework. For this purpose, eight primary vessel classes were identified from the literature—fishing boat, bulk carrier, general cargo vessel, tanker, container ship, passenger ship, tugboat, and warship—and a large, balanced dataset was constructed by combining images obtained from different sources. Preprocessing techniques such as rotation, flipping, scaling, noise reduction, and super-resolution were applied to enhance the model's learning capability. In the methodology section, 21 different deep learning architectures (including NasNet, ResNet, DenseNet, GoogleNet, Inception, VGG, Xception, EfficientNet, DarkNet variants, the R-CNN family, RetinaNet, and YOLOv8) will be employed for feature extraction to ensure architectural diversity. The deep features obtained from these models will be optimized using five different feature selection methods (mRMR, Chi², ReliefF, ANOVA F-test, and Kruskal–Wallis), enabling the selection of the most informative attributes. Subsequently, combinations of "model and feature selection algorithm" pairs will be compared to determine the structure with the highest accuracy and lowest computational cost. In project management, the stages of data preparation, model training, feature extraction, feature selection, combination comparison, and reporting have been scheduled over a 12-month timeline. Alternative solutions and contingency plans have been developed for risks such as hardware limitations, class imbalance, and multi-source image incompatibility. The broader impact of this research lies in contributing to the development of an AI infrastructure that reduces dependence on AIS, enhances dark-ship detection, and supports both military and civilian maritime surveillance systems. The integration of imagery from platforms such as UAVs and USVs increases the practical applicability of the study and provides a foundation for future smart coastal security systems and autonomous marine vehicles.

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OPERATİONAL COMPARİSON OF LİGHTWEİGHT DEEP LEARNİNG ARCHİTECTURES FOR UNDERWATER PİPELİNE DETECTİON AND TRACKİNG İN EMBEDDED SYSTEMS

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Abstract – Autonomous surveillance missions for subsea pipelines and critical infrastructure hold strategic importance for ROV (Remotely Operated Vehicle) and AUV (Autonomous Underwater Vehicle) platforms. In these missions, traditional image processing methods often prove unreliable and insufficient in providing the necessary robustness due to severe optical limitations (light scattering, low contrast) imposed by the underwater environment. Furthermore, the restricted energy budget and low data transmission bandwidth of underwater vehicles necessitate that the decision-making process occurs onboard the system and in real-time. This study addresses the operational rationale and lessons learned from the transition from traditional image processing to Deep Learning models. For this purpose, an optimized MobileNetV2 based object detection model was trained for deployment on a low-power Raspberry Pi and Coral TPU hardware architecture. The model underwent quantization and optimization processes to ensure suitability with the hardware constraints. The paper presents a comparative analysis of the model developed by our team, alongside other leading lightweight deep learning architectures. The evaluation is focused not only on detection accuracy (mAP) but also on critical operational metrics such as latency, frames per second (FPS) performance, and power consumption. Additionally, the robustness of all models against increased underwater turbidity and noise is rigorously tested. The study identifies the shortcomings of current methods based on comparative results and offers concrete recommendations for the ideal model and hardware combinations that can be utilized for achieving higher performance and reliability in future development cycles.

Keywords – ROV/AUV; Underwater Imaging; Pipeline Detection; Image Processing; MobileNetV2; Model Comparison

A COMPARATIVE REVIEW OF ELECTRO-HYDROSTATIC ACTUATORS WITHIN THE SCOPE OF ELECTRIC AIRCRAFT TECHNOLOGIES

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Abstract – The More Electric Aircraft (MEA) concept, developed to increase efficiency and reduce weight in the aviation industry, has brought about profound changes in flight control systems. At the core of this transformation, Electro-Hydrostatic Actuators (EHA) stand out as an innovative technology that eliminates reliance on central hydraulic systems. The aim of this study is to analyze the working principles of EHA systems and to theoretically demonstrate the advantages they provide compared to Conventional Servo-Hydraulic (SHA) and Electro-Mechanical (EMA) actuators. A literature review and comparative analysis method were employed in the study. The findings indicate that EHA minimizes energy consumption through the "Power-on-Demand" principle, provides significant weight savings by eliminating central pipelines, and facilitates maintenance processes due to its modular structure. However, thermal management issues arising from its closed-loop architecture have been identified as the primary constraint of the technology. Consequently, EHA technology, offering high power density and reliability, is envisaged to be considered one of the most suitable solutions for future flight control systems.

Keywords – Electro-Hydrostatic Actuator (EHA), More Electric Aircraft, Flight Control Systems, Power-by-Wire, Energy Efficiency.

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AUTONOMOUS SWARM TECHNOLOGİES AND TRANSFORMATİON İN MODERN WARFARE

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Abstract – This study aims to examine the transformation created by autonomous swarm technologies in modern warfare doctrines through their technical foundations. In recent years, advances in processor capacity, sensor technologies, communication protocols, and AI-based control algorithms have rendered swarm systems composed of multiple agents strategically significant in the military domain. The paper addresses the fundamental components of swarm architecture from an engineering perspective, including static and dynamic swarm structures, distributed control algorithms, mission planning methods, communication topologies, and multi-layered security designs. Furthermore, operational parameters such as intra-swarm coordination, data sharing, sensor fusion, target detection, energy optimization, and fault tolerance during missions are analyzed in detail. The article integrates both theoretical foundations and practical field applications, presenting a holistic development process that spans from simulation-based validation methods to real-world scenarios. Within this context, technical countermeasures against electronic warfare threats such as communication disruptions, GNSS spoofing, and jamming are systematically evaluated. The study also emphasizes the ethical, legal, and operational boundaries of swarm systems, underlining the necessity of human-supervised autonomy.

In conclusion, this paper serves as a comprehensive reference for engineers and researchers aiming to design, implement, and field-test autonomous swarm systems. The methods and technical guidance presented support the effective, reliable, and scalable deployment of swarm technologies in modern defense applications.

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CUSTOM CONTROL BOARD DESİGN AND DRİFT-COMPENSATED NAVİGATİON FOR UNDERWATER ROCKETS

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Abstract – This paper presents the design and implementation of a custom avionics system for an autonomous underwater rocket (SARA), developed within the scope of the TEKNOFEST Underwater Rocket Competition. Conventional underwater vehicle control systems often rely on high-cost sensors like Doppler Velocity Logs (DVL) to correct Inertial Measurement Unit (IMU) drift or require complex, bulky cabling architectures that are unsuitable for the compact hydrodynamics of an underwater rocket. To address these challenges, this study proposes a low-cost, integrated Printed Circuit Board (PCB) solution centered around the STM32F103C8T6 microcontroller and the BNO055 absolute orientation sensor. The proposed system features a sensor fusion algorithm that utilizes the BNO055's on-chip Cortex-M0+ processor to minimize double integration errors and drift, eliminating the need for expensive external reference sensors. Furthermore, a custom PID control algorithm, tuned specifically for high-damping underwater dynamics, is implemented to ensure precise heading hold during the cruising phase and a stable 30-degree pitch angle for the rocket ignition phase. The hardware design also integrates solid-state MOSFET technology for safe ignition and hardware-level filtering for servo motor signal stability, replacing unreliable mechanical relays and eliminating signal noise during system boot. Experimental results and pool tests demonstrate that the proposed system successfully mitigates sensor drift, reduces internal cabling volume by 90%, and fulfills the autonomous navigation and ignition tasks required by the competition specifications with high reliability and cost-efficiency.

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INTELLIGENT PROPULSION CONTROL SOFTWARE IN ELECTRIC MILITARY VEHICLES

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Abstract - This study presents the design of a highly accurate, robust, and autonomously adaptable intelligent guided control software architecture for electric military vehicles. The research employs a multi-layered control method to ensure high torque control, energy efficiency, quiet operation, and fault tolerance in the variable regime conditions of military operations. The integration of advanced algorithms from the literature with real-time decision-making updates forms the basic theoretical framework of the product. In the proposed system design, motor driver modules, sensor-based sensor settings, energy management programs, and mission-oriented vehicle control software are integrated into a unified architecture. This architecture, structured with a model-based development approach, is both high-performance and modular, adaptable to different military vehicle specifications. Furthermore, intelligent calculations such as logical reasoning, adaptive control, and predictive control are used for safety system configuration; thus, stable and safe movement is achieved even in challenging terrain conditions. The implemented alternative processes demonstrate a recovery of value achieved by the proposed software in both energy consumption and support. In tests conducted under different scenarios, the system achieved torque-speed management with high accuracy, demonstrated resilience to sensor errors, and exhibited the ability to quickly respond to unexpected response changes. Consequently, the study makes significant contributions to the development of reliable and real-time guided control software that enhances the capabilities of electric military vehicles. Furthermore, it provides a flexible basis for future autonomous military platforms.

Keywords- *Propulsion Control; Electric Military Vehicles; Embedded Systems; Power Management; Vehicle Dynamics Modeling.*

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CAMERA SYSTEMS AND IMAGE PROCESSING TECHNIQUES USED IN AIR DEFENSE SYSTEMS

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Abstract- The effectiveness of modern air defense systems is determined not only by their radar-based detection capabilities, but also by the high-resolution visual information provided by electro-optical (EO) and infrared (IR) camera systems. Increasingly diverse and altitude-profile weather threats, particularly micro and mini-UAVs, low-radar track platforms and camouflaged elements, have shown that traditional sensors alone are not enough. This study examines the EO, IR, SWIR, multispectral and hyperspectral camera technologies used in air defense systems; and evaluates the role of these sensors in target detection, classification, monitoring and threat verification processes. They also cover image processing techniques, deep learning-based object detection, sensor fusion algorithms and real-time target tracking methods, which are widely used in modern air defense architecture. The study highlights the operational contributions of radar-camera integration and discusses the advantages of optical systems under low visibility conditions. Finally, the next generation of image processing solutions developed against artificial intelligence-assisted autonomous air defense approaches, hyperspectral imaging systems and micro-UAV herds are presented as future trends. This paper aims to provide the basis for future research by revealing the critical importance of camera-based air defense systems in the evolving threat environment.

DEVELOPING EMBEDDED AVIONICS SYSTEM FOR MODEL ROCKETS

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Abstract- This study presents the design and development process of a model rocket avionics system, focusing on sensor selection, communication protocols, power budgeting, and PCB implementation. The avionics architecture was established by first identifying mission-critical sensor requirements and evaluating their electrical characteristics through datasheet-driven analysis. Communication interfaces were selected to ensure reliable and noise-resistant data transfer under dynamic flight conditions. A detailed power budget was created to define regulator specifications and ensure stable system operation throughout the mission profile. Microcontroller pin assignments and subsystem interconnections were optimized based on functional dependencies and electrical constraints. The hardware design phase included schematic creation for all sensors and peripherals, followed by PCB layout optimization using Saturn PCB toolchains to analyze trace widths, via parameters, and spacing rules relative to current capacity and signal integrity. Multiple design iterations (V1–V2) improved mechanical compliance, electromagnetic robustness, and manufacturing feasibility. The final avionics board design demonstrates a compact, efficient, and mission-ready solution suitable for model rocket applications. The results confirm that systematic analysis and structured design methodology significantly enhance reliability and performance in small-scale aerospace electronics.

CONTROLLING UNMANNED GROUND VEHICLES WITH HAND GESTURES

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Abstract – This study systematically investigated thirty scientific articles focusing on the hand gesture control of mobile robots, Unmanned Aerial Vehicles (UAVs), and various other robotic systems. Different sensing technologies—including RGB and depth cameras, smart gloves, and EMG sensors-were comparatively analyzed alongside gesture recognition approaches based on rule-based methods, classic machine learning, and deep learning. The findings reveal that the majority of current applications concentrate on fundamental command sets involving a small number of gestures. However, deep learning-based methods demonstrate superior accuracy and robustness in handling more complex recognition scenarios. The discussion section provides several recommendations for future research, focusing on hybrid sensor architectures, the integration of high-level gesture commands with autonomous navigation, and the design of safe, user-friendly interactions under real-world field conditions.

Keywords – Hand Gesture Recognition; Gesture-Based Robot Control; Human-Robot Interaction (HRI); Mobile Robots; Unmanned Vehicles; Deep Learning; Wearable Sensors; Depth Cameras

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DESIGN OF MODERN AESA RADAR SYSTEMS: ARCHITECTURAL CONSTRUCTION, BEAMFORMING, THERMAL MANAGEMENT AND ELECTRONIC WARFARE RESISTANCE

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Abstract- Active electronic controlled phase array (AESA) radars form the basis of modern radar architecture with features such as electronic beam routing capability, multi-tasking support and high reliability. It is clearly stated in the literature that phase array antennas provide high gain, flexible beam control and low side lobe levels in multifunctional radar applications [1]–[2]. Current studies indicate that there is a strong interdependence between the antenna array architecture of AESA radars, T/R module technology, beamforming structure and thermal requirements; therefore, the analysis of radar performance can only be carried out with the objective assessment of these sub-components is correct. This article examines the architectural structure of modern AESA radars, their basic components, the principles of beamforming, and the effects of power/thermal management on system performance in a systematic framework; it also discusses the reflections of resistance mechanisms and emerging technologies in the electronic warfare environment on radar design.

AUTOMATIC 3D ROAD NETWORK MODELING FROM SATELLITE IMAGERY: A DEEP LEARNING-BASED HYBRID APPROACH

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Abstract – The creation of digital twins for urban areas is of increasingly critical importance in smart city applications, urban planning, and simulation processes. However, the generation of 3-dimensional (3D) models from satellite imagery using traditional methods is a time-consuming, labor-intensive, and high-cost process. In this study, an end-to-end hybrid method is employed for the automatic detection and 3D reconstruction of road networks from satellite imagery using deep learning algorithms. Within the scope of the study, the U-Net architecture, which has proven success in semantic segmentation tasks, was utilized; the training of the model was conducted on high-resolution satellite images diversified through data augmentation techniques. The 2D segmentation masks obtained from the deep learning model were converted into vector data via geometric processing algorithms and procedurally transferred into 3D space. Experimental results demonstrate that the proposed model achieved 94.2% Pixel Accuracy and 78.5% Intersection over Union (IoU) on the test data. Visual analyses prove that the model accurately distinguishes road geometry even in areas with complex background textures and that the generated 3D models maintain topological integrity. This study reveals that deep learning-assisted approaches present an effective solution for the rapid and cost-effective 3D modeling of large-scale urban infrastructures.

Keywords – Deep Learning, U-Net, 3D Modeling, Satellite Imagery, Road Detection.

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COGNITIVE ELECTRONIC WARFARE TECHNIQUES FOR THE DETECTION OF LOW PROBABILITY OF INTERCEPT (LPI) RADARS

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Abstract - Low probability of intercept (LPI) radars are systems that are difficult to detect by conventional electronic support receivers due to their low peak power, wideband waveforms, and energy distributions embedded within the noise floor. Modulation techniques such as frequency and phase coding spread the signal energy across the time-frequency plane, effectively rendering the waveform inconspicuous. Operational characteristics such as randomly generated pulse repetition intervals, low effective power levels, and rapid frequency hopping further reduce the probability of detection. As a result, traditional threshold-based and statistical detection methods become insufficient on the modern battlefield, creating the need for more flexible and adaptive structures capable of learning and distinguishing LPI signals. This study presents an integrated approach for the detection of LPI radars by combining the perception-learning-adaptation cycle of cognitive electronic warfare with electronic support systems. The processing of time-frequency analyses using artificial intelligence-based models, the separation of complex pulse trains through object detection techniques, and the enhancement of detection performance under low signal-to-noise ratio conditions using deep neural networks are investigated. Findings indicate that cognitively designed systems can learn not only known signals but also previously unseen waveforms through environmental feedback and can adapt their decisions accordingly.

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AUTONOMOUS NAVIGATION AND OBSTACLE DETECTION IN UNMANNED GROUND VEHICLES

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Abstract – This research investigates current approaches for autonomous navigation and obstacle detection methods in Unmanned Ground Vehicles (UGVs). A total of 27 articles were reviewed within the scope of this study, comparing techniques such as sensor fusion, image processing, deep learning, LiDAR and radar-based sensing, and navigation strategies in GPS-denied environments. The findings indicate that hybrid sensor architectures provide more robust obstacle detection compared to single-sensor systems. Furthermore, memory-driven mapping and probabilistic modeling significantly reduce the margin of error in dynamic environments. Image-based methods were determined to offer high performance, especially in complex terrain conditions, but were found to be susceptible to changes in lighting and image noise. The study also identified deep reinforcement learning as an emerging approach in route planning and collision avoidance applications. The results suggest that, in the future, real-time computation, hardware costs, sensor integration, and open-source software infrastructure will directly influence the performance of autonomous ground vehicles.

Keywords – Autonomous Navigation; Unmanned Ground Vehicles (UGV); Obstacle Detection; Sensor Fusion; Deep Learning; Image Processing

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RADAR IDENTIFICATION WITH ELECTRONIC WARFARE SYSTEMS: METHODS, PARAMETRIC ANALYSIS AND DETECTION THEORY-BASED ASSESSMENTS

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Abstract – Radar identification has become a critical component in ensuring friend–foe discrimination, situational awareness, and the accuracy of engagement decisions within a complex electromagnetic threat environment. In this context, the study systematically examines the primary identification methods used in electronic support and electronic intelligence systems, evaluating the strengths and limitations of techniques based particularly on temporal, frequency-domain, spatial, and statistical features. Within the scope of parametric signal analysis, the contribution of fundamental radar parameters—such as carrier frequency, pulse repetition interval, pulse width, pulse amplitude, modulation type, and antenna scanning characteristics—to identification accuracy is detailed. Furthermore, the effects of signal-to-noise ratio, threshold-setting strategies, and performance metrics on identification processes are discussed through the core concepts of radar detection theory, namely probability of detection and probability of false alarm. By presenting an integrated assessment of existing methods for discriminating radar signals, this study aims to provide a theoretical basis for developing more reliable, faster, and higher-accuracy identification mechanisms in modern electronic warfare systems.

*Keywords –*Radar Identification; Electronic Warfare; Parametric Signal Analysis; Radar Detection Theory; AI-Based Signal Processing

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NUMERICAL INVESTIGATION OF AERODYNAMIC HEATING AND SHOCK CHARACTERISTICS OF THE 5.56X45 MM PROJECTILE UNDER SUPERSONIC FLIGHT CONDITIONS

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Abstract – Aerodynamic heating constitutes a critical aspect of high-speed projectile flight, particularly under supersonic conditions where compressibility effects and shock-induced phenomena become significant. In the present study, the transient aero-thermal behavior of a 5.56×45 mm projectile is investigated using two-dimensional axisymmetric numerical simulations with a prescribed time-dependent flight velocity profile. The simulations are performed for supersonic freestream conditions in which the Mach number varies within the range of 2.7 to 1.8 during the considered flight duration. Density-based solver with implicit time integration is employed in conjunction with the Spalart–Allmaras one-equation turbulence model to provide a reliable representation of compressibility effects, shock wave structures, and boundary-layer behavior in high-speed external aerodynamic flows with reasonable computational efficiency. Adiabatic wall boundary conditions are applied to evaluate the adiabatic wall temperature distribution as an indicator of aerodynamic heating. The numerical results are analyzed to examine the adiabatic wall temperature along the projectile surface, the development of shock structures around the projectile, and the corresponding wall pressure ratio distributions throughout the prescribed flight history

Keywords – Aerodynamic Heating; Shock Wave; 7.62×51 mm projectile; CFD; Adiabatic Wall Temperature

ARTIFICIAL INTELLIGENCE SUPPORTED DATA FUSION FOR SITUATIONAL AWARENESS ON THE BATTLEFIELD

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Abstract- Modern battlefields; characterized by high uncertainty, variable threat intensity, electromagnetic complexity, complex geophysical conditions and multilayer operation structures. For this reason, the effectiveness of the decision-making processes of the military units is determined not only by firepower, but by information superiority. Situational awareness (situational awareness – SA) has become one of the most critical components of command control (C2) systems and unmanned systems. Situational awareness; is a three-step process of perception, understanding and foreseeing the future. This process depends on the correct processing of heterogeneous data from different sensors. Although the variety of sensors used in the battlefield (radar, electro-optical, IR, acoustic, IMU, RF, LiDAR, etc.) is a great advantage in detecting threats, the individual processing of these data is often insufficient. Therefore, data fusion is at the heart of modern defense technologies (1). Traditional fusion methods (Kalman filters, Bayesian methods, Dempster–Shafer theory) have been used for many years. However, these methods can perform only in dynamic, noisy, chaotic combat environments (2). On top of that, artificial intelligence-supported approaches such as deep learning, graphic neural networks, transformer-based fusion have been on the rise in the literature (3)(4). In particular, FPGA-based embedded artificial intelligence solutions and real-time multi-sensor processing architectures offer low-latency decision-making in the field (5).

ELECTRONIC WARFARE TECHNOLOGY

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Abstract – Electronic warfare (EW) has become a decisive capability in modern operations by enabling control, exploitation, and protection of the electromagnetic spectrum. As radar, communications, and navigation systems increasingly rely on congested and dynamic spectral resources, EW architectures are evolving from threat-specific countermeasure suites into continuously sensing, data-driven, and adaptive systems. This paper presents a comprehensive literature-based review of EW technology, covering core concepts and operational roles, and detailing the functional interplay of Electronic Support (ES/ESM), Electronic Attack (EA/ECM), and Electronic Protection (EP/ECCM) as the basis for spectrum dominance. The study further analyzes the end-to-end operational flow of contemporary EW systems— signal interception, RF front-end conditioning, direct wideband RF sampling, parameter extraction, emitter identification, deinterleaving in dense environments, decision-making, and countermeasure generation—highlighting enabling subsystems such as wideband antennas, multifunction RF front ends, RFSoC/FPGA-based digital receivers, DRFM-based deception units, and GaN power amplifiers. In addition, radar–EW interaction is examined as a multi-layer spectral competition shaped by AESA, ultra-wideband and LPI waveforms, agility-driven ECCM, and the rise of cognitive/adaptive approaches. Finally, the paper discusses emerging directions expected to redefine EW in the near and long term, including distributed multi-platform EW networks, AI-driven emitter recognition and response selection, reconfigurable transceiver architectures, and quantum sensing concepts. Overall, the findings indicate that future EW will be increasingly characterized by real-time learning, predictive decision-making, and tightly integrated hardware–software co-design to maintain operational advantage in contested spectrum environments.

Keywords – Electronic warfare, Electronic support (ES/ESM), Electronic attack (EA/ECM), Electronic protection (EP/ECCM), electromagnetic spectrum dominance, RF front-end, direct RF sampling, RFSoC, FPGA, DRFM, GaN power amplifier, radar–EW interaction, AESA radar

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ARTIFICIAL INTELLIGENCE BASED UAV IN DIGITAL MOTION MAP SYSTEMS

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Abstract- Unmanned aerial vehicles (UAV/UAV) have become critical platforms used in recent years in a wide range of missions, including surveillance, reconnaissance, search and rescue, disaster management, agricultural spraying, cargo transportation and last-mile parcels delivery in both military and civilian applications. The UAVs offer advantages such as lower cost, higher maneuverability, access to risky areas without endangering human life and operational flexibility compared to manned aircraft (1), (6), (10), (11), (10), (1) The success of these tasks depends not only on the hardware and aerodynamic characteristics of the UAVs, but also on the success of the mission and route planning algorithms. (1, visit the most critical areas within a limited tenure of a UAV fleet engaged in regional exploration (4), delivery of post-disaster emergency supplies to their needs as soon as possible, or balance between customer satisfaction and cost in final mileage delivery, basically response to route optimization problems)Rota planning problems are modeled in the literature as derivatives of well-known combinatorial optimization problems (such as Traveler Seller Problem (GSP), Vehicle Rotation Problem (ARP/VRP) and Orientering Problem (OP); energy/battery constraints specific to UAVs, three-dimensional motion capability, forbidden tip) (16), (17).

EFFECT OF BOAT-TAIL ANGLE ON THE AERODYNAMIC CHARACTERISTICS OF THE 5.56X45 MM PROJECTILE UNDER SUPERSONIC REGIME

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*Abstract –*The aerodynamic characteristics of projectile afterbody geometry play a significant role in determining base drag and wake behavior under supersonic flight conditions. In the present study, the effect of rear cone (boat-tail) angle on the transient aerodynamic behavior of the 5.56x45 mm projectile is investigated through two-dimensional axisymmetric numerical simulations. A parametric analysis is conducted by varying the rear cone angle while prescribing a time-dependent freestream velocity profile representative of the supersonic portion of the projectile flight. The simulations are conducted for Mach numbers ranging from 1.8 to 2.3 using a transient, implicit density-based solver coupled with the Spalart–Allmaras turbulence model to provide a reliable representation of compressibility effects, shock wave structures, and wake dynamics. The projectile surface is modeled using no-slip wall boundary conditions, and atmospheric pressure is applied at the far-field boundaries. The numerical results are analyzed to examine the influence of rear cone angle on the temporal evolution of base pressure, wake structure, shock formation in the afterbody region, and the resulting aerodynamic pressure distributions along the projectile surface throughout the prescribed flight history.

Keywords – Boat-tail Angle; Shock Wave; 7.62×51 mm projectile; CFD; Wake Structure

THE EFFECTS OF PORTABLE ELECTRIC VEHICLE CHARGING STATIONS ON DEFENSE MOBILITY IN CRITICAL MISSION AREAS

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***Abstract** –* The aim of this study focuses on the exchange of battery systems used in the conversion of internal combustion engine vehicles to alternative fuel electric vehicles in the military field. Currently, existing electric vehicles are used with internal battery systems. Military vehicles located in critical mission areas would be deprived of operational capability during the time spent charging their onboard batteries. The effects of using swappable (rapid plug-remove-replace) batteries in military vehicles on defense mobility have been investigated. A study was conducted on charging these batteries with portable electric vehicle charging stations. It is known that the effective use of time in terms of operational capability is inevitable for carrying out uninterrupted and non-stop operations in mission-critical areas regarding defense mobility while performing electric vehicle conversions used in the military field. With the development of battery technologies, the stored energy density per unit weight is increasing. In this study conducted on the use of electric motor vehicles in mission-critical areas, it was observed that it enhances defense mobility.

Keywords – Military Electric Vehicles; Portable electric vehicle charging stations; Battery Technologies.

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MACHINE LEARNING-BASED UAV DETECTION AND COUNTERMEASURE SYSTEMS: AN INTEGRATED SMART DEFENSE APPROACH USING LASER AND ELECTROMAGNETIC METHODS

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Abstract – This study addresses the difficulties encountered in detecting UAVs despite recent advances in UAV defense technologies, as well as the inadequacy of existing countermeasure systems compared to the UAVs being produced. Within this scope, multiple data obtained from radar, EO/IR, RF/SDR, acoustic, and LiDAR sensors are combined in a machine learning-based fusion layer to perform UAV detection, classification, and threat leveling. Depending on the threat level obtained, the aim is to automatically provide a decision on soft neutralization (jamming/deception) via software-defined radio (SDR) or hard neutralization with directed energy systems (laser/HPM). The proposed architecture incorporates both real-time detection processes and predictive engagement modules, offering a comprehensive approach to the analysis and neutralization of modern UAV threats.

Keywords – Counter-UAS (C-UAS); Multi-Sensor Fusion; Radar Micro-Doppler Analysis; RF Signal Analysis; EO/IR Imaging; Acoustic Drone Detection; Convolutional Neural Networks (CNN); Passive Radar; SDR-Based Detection

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A LITERATURE REVIEW ON THE PROCESSABILITY OF THE MAIN MATERIALS USED IN THE DEFENSE INDUSTRY SECTOR

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Abstract – Machining is a widely used manufacturing method today, frequently employed to give materials their final shape. Materials used in the defense industry require shaping within a precise tolerance range and with high surface quality. Therefore, examining the machinability of materials used in this sector will both identify areas of focus in research and demonstrate the frequency of material use. This brief literature review evaluates the machinability criteria of materials frequently used in the defense industry, considering the main machining methods (turning, milling, drilling, etc.). The findings reveal that high-strength steels and aluminum alloys (29%) are used more frequently in this field, while titanium alloys and composite materials (12%) are also commonly used. Nickel-based superalloys, stainless steels, and magnesium alloys (6%) are less preferred compared to other materials. The aim is to contribute to the defense industry sector by reflecting the machining methods and material diversity of the findings.

Keywords – Defense industry; Machinability; High-strength steel; Aluminum

DESIGN AND KINEMATIC ANALYSIS OF A SIX-AXIS ROBOT ARM INTEGRATED WITH A CONVEYOR BELT

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Abstract – Thanks to advancing technologies, robotic arms are rapidly being adopted across nearly all sectors in many areas of industry. Robotic arms, which are constantly evolving, are becoming indispensable for systems that can be automatically coded and operate in series. This study presents the design, kinematic analysis, structural strength assessment, and control infrastructure of a multi-axis robotic arm integrated with a conveyor belt system for industrial automation applications. In today's production systems, there is a growing need for flexible, low-cost, and reconfigurable robotic solutions. Developed in line with this need, the system aims to provide an effective solution for light load carrying and repeatable material transfer operations. The mechanical design of the robotic arm was carried out using Computer-Aided Design (CAD) software, and all components were modeled in three dimensions in the SolidWorks environment. The designed parts were manufactured using PLA-based filaments with additive manufacturing methods. The robotic arm's mobility is provided by joints driven by servo motors, and the system is configured to have 6 degrees of freedom. The forward and inverse kinematic analyses of the robotic arm were performed in the SolidWorks program to ensure positioning accuracy. To evaluate the structural reliability of the system, static stress analyses were performed on critical components, taking into account the load capacity and appropriate safety factors. The control infrastructure was developed using an Arduino-based microcontroller; the synchronous operation of the servo motors and the coordination between the robotic arm and the conveyor belt were successfully achieved. The findings indicate that the developed robotic arm and conveyor belt system can be effectively used in educational robotic platforms, laboratory automation, and low-cost industrial applications. Furthermore, due to its modular structure, the system is considered open to further development in terms of integration with image processing-supported object recognition, advanced control algorithms, and Industry 4.0-compatible smart production systems.

Keywords – *Robotic arm, Design, Conveyor belt, Integrated system, Analysis*

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