ABSTRACT BOOK

7th-9th June

ISUDEF'23

International Symposium on Unmanned Systems: AI, Design & Effeciency

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T. Hikmet KARAKOÇ - Ricardo VINUESA - Rafaello MARIANI
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International Symposium on Unmanned Systems: AI, Design and Efficiency

ISUDEF'23 Abstract Book

International Sustainable Aviation and Energy Research Society

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International Symposium on Unmanned Systems: AI, Design and Efficiency 2023 (ISUDEF'23) Edited by Prof. Dr. T. Hikmet Karakoc, Assoc Prof. Dr. Ricardo Vinuesa, Assoc Prof. Dr. Raffaello Mariani, Asst. Prof. Dr. Gerardo Zampino, Asst. Prof. Dr. Ali Haydar Ercan, Assoc Prof. Dr. Selcuk Ekici, Asst. Prof. Dr. Alper Dalkıran., Dr. Emre Özbek.

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This book contains abstracts submitted to International Symposium on Unmanned Systems: AI, Design and Efficiency 2023 (ISUDEF'23).

T. Hikmet Karakoç
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Ricardo Vinuesa
Symposium Chair

Raffaello Mariani
Symposium Chair

Gerardo Zampino
Symposium Chair

Message from the Symposium Chairs

It is a great pleasure to publish the abstract book of International Symposium on Unmanned Systems: AI, Design and Efficiency (ISUDEF'23), held in Online Mode on June 7th – 9th 2023.

Unmanned systems are one of the fastest growing and widely developing technologies in the world, offering several possibilities for a variety of research fields, including the defence industry. As we are in an era in which there is continuous progress in unmanned systems, we would like to invite researchers, scientists, engineers, practitioners, policymakers, and students to the International Symposium on Unmanned Systems: AI Design and Efficiency to exchange information, present new technologies and developments, and discuss the future direction, strategies, and key priorities moving forward.

ISUDEF'23, an international, multi-disciplinary symposium, aims to address current topics on unmanned systems industry in such broad areas as aerial, naval and land applications; avionics; radar systems AI Design and Efficiency. Specifically, researchers may wish to present their solutions and insights on such topics as platform designs, AI integration, robotics, and autonomous systems to provide innovative solutions to the challenges facing the homeland UAV industry, along with civilian applications.

ISUDEF'23 included several keynote presentations, industrial specialized sessions and oral & poster presentation sessions from participants on different subjects submitted. We look forward to welcoming you to this remarkable event in June 2023.

Sincerely,

Hikmet Karakoç (Symposium Founding Chair), Ricardo Vinuesa, Gerardo Zampino & Raffaello Mariani (Symposium Chairs)

Lifetime Honorary President of SARES

Maximillian Platzer

Symposium Founding Chair

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Contents

KS01
Direct numerical simulation of a thermal turbulent boundary layer: an analogy to simulate bushfires and a testing bed for artificial intelligence remote sensing of bushfire propagation.

Julio Soria

Monash University, Melbourne, Australia

Abstract: Direct numerical simulation (DNS) of a thermal turbulent boundary layer can simulate bushfires and serve as a testing bed for AI remote sensing of bushfire propagation. By solving the Navier-Stokes equations for a turbulent flow, DNS predicts the flow field and allows for a detailed study of the interactions between turbulent flow and thermal plumes. This provides insights into complex bushfire behaviour such as the effects of wind, topography, and fuel load. DNS can generate synthetic remote sensing data to train artificial intelligence (AI) algorithms such as convolutional neural networks (CNNs) and recurrent neural networks (RNNs), which can process large amounts of remote sensing data associated with bushfire. Using DNS results as training data can improve the accuracy of AI remote sensing in predicting bushfire propagation in different scenarios. DNS can also test the accuracy of the AI remote sensing algorithms by generating synthetic remote sensing data to assess their performance in predicting the evolution of a bushfire. The combination of DNS and AI can improve our understanding of bushfire dynamics, develop more accurate prediction models, and aid in bushfire management and mitigation.

Keywords: bushfires, direct numerical simulation, thermal turbulent boundary layer, remote sensing, artificial intelligence

KS02
Student UAV projects at KTH.

Raffaello Mariani

KTH Royal Institute of Technoogy, Sweden

Abstract: New emphasis has been given since 2019 to enhance education and research at KTH in future aviation by taking both "out of the laboratory and the classroom" and into the field, based on four pillars: education, research, multidisciplinarty, and industry. A focus on multidisciplinary and inter-school collaborations was emphasized in order to address the challenges of the future. As a result, initially one project was launched focusing on the development of a blended-wing-body unmanned aerial vehicle powered by a compressed hydrogen fuel cell and lithium polymer battery to present the students in several programs to work on interesting and relevant research topics. Following this more research-focused project, two more projects have been initiated: Autonomous Light Platform for High Altitude atmospheric Imaging (ALPHA), and the Solar-Powered Forest Monitoring UAV (SOLFAR), which represent all four of the pillars of this new emphasis at KTH. The current talk will present the key challenged encountered and the path towards a stronger and applied education.

Keywords: aerodynamics, wind tunnel testing, aircraft design, compressible flow

KS03
Unmanned aerial vehicles cooperation for the monitoring of greenhouse gases.

Glauco Caurin

University of São Paulo, Brasil

Abstract: Climate change is one of the most significant challenges that humanity is facing in the 21st century. In this context, monitoring the emission of greenhouse gases in the Amazon Forest is receiving special attention from the scientific community. Different types of unmanned aircraft can be designed to operate at different altitude conditions. Additionally, unmanned aircraft may provide high-frequency and high-resolution imaging and data collection if compared with satellites. However, given the complexity of the task, no single aerial platform can fulfill all mission requirements. In addition to the aerial platforms themselves, the weight, volume, and robustness of sensors for measuring greenhouse gases and climatic magnitudes need to be taken into account. Another challenge is data processing and storage. With the amount of data collected by aircraft, new technologies such as embedded systems, neural networks, containers, and cloud processing may offer attractive solutions to efficiently process and store data. The use of unmanned aircraft for monitoring the Amazon Forest is a promising technology. The use of new technologies can help address these challenges and offer new perspectives for data capture, pre-processing, storage, and communication.

Keywords: autonomous systems, interaction control, embedded systems, neural networks

KS04
Marine Autonomy: Research and Applications.

Sanjay Sharma

University of Plymouth, England, UK

Abstract: Marine autonomy does not have as many constraints as there are on land but there are still challenges that need to be overcome to make the most of current and future opportunities. My talk will concentrate on the research works done in the marine autonomous systems research group at Plymouth where the focus of the research group has been towards application of AI techniques to the navigation, guidance, and control of autonomous marine vehicles. The talk will also discuss future challenges in the marine autonomy areas and their likely solutions.

Keywords: artificial intelligence (AI), advanced control systems engineering, multi-sensor data fusion, integrated navigation systems, application of ai techniques to the navigation, guidance, and control of autonomous marine vehicles

KS05
UAV noise: integrating biodiversity assessment into sustainable aviation.

Mike Wood

University of Salford, UK

Abstract: Rapid growth in the development and use of Unmanned Aerial Vehicles (UAVs) brings significant potential benefits, including low-carbon transportation, reduced road congestion and the ability to rapidly move goods through rural environments where surface transport networks are lacking. However, there are also potential costs associated with this widespread introduction of UAVs. The growth in UAV use will change the noise environment in the areas where UAVs operate and, in rural areas especially, bring a significant increase in noise pollution. It has long been recognised that noise pollution is a harmful stressor for both humans and wildlife. In charting a path towards sustainable UAV deployment, there is a need to understand the implications of the changing noise environment. One of the Work Packages within the the EC RefMap project (https://www.refmap.eu/; 2023-2026), focuses on noise pollution from UAVs and its impacts on humans and wildlife. This presentation will provide an overview of that research and outline the initial development of an approach to assessing and managing the impacts of UAV noise pollution on wildlife.

Keywords: noise, biodiversity, wildlife, unmanned aerial vehicle, sustainability

KS06
Reduced order models and machine learning in aerospace engineering.

Soledad Le Clainche Martínez

Universidad Politécnica de Madrid (UPM), School of Aeronautics, Spain

Abstract: Modelling turbulent flows solving the engineering problem mentioned, is a highly complex task that requires a large amount of computational resources. The alternative is developing Reduced order models (ROMs) using (among others): (i) modal decompositions (i.e., singular value decomposition – SVD, higher order dynamic mode decomposition - HODMD), (ii) clustering based methods (i.e. principal component analysis - PCA and local PCA) and (iii) machine learning tools. The main goal of this work is applying these techniques to solve several engineering problems with applications in aerospace engineering, presenting new strategies to develop efficient and accurate ROMs. More specifically, HODMD is used to identify the main patterns and to develop a ROM in an axisymmetric, time varying, non-premixed co-flow flame and, PCA and LPCA are applied to develop a ROM in a synthetic jet. Finally, machine learning tools (artificial neural networks) are combined with modal decompositions (SVD) to develop a novel and efficient ROM.

Keywords: fluid dynamics, machine learning, reduced order models, data analysis, flow patterns

KS07
Nontraditional attitude filtering with uncertain process noise.

Chingiz Hajiyev

Istanbul Technical University, Türkiye

Abstract: In this study the Extended Kalman Filter (EKF) and Singular Value Decomposition (SVD) methods are integrated in the nontraditional attitude filtering algorithm to estimate a small satellite's attitude. It is shown that, the process noise bias and process noise increment type system changes will cause a change in the statistical characteristics of the innovation sequence of EKF. Influence of these type of changes to the innovation of EKF is investigated. It is proved that the bias type process noise change may be converted to the mean square of innovation of EKF and such type of changes can be compensated using the covarince scaling techniques.

Keywords: nanosatellite, attitude estimation, process noise, extended Kalman filter, singular value decomposition

KS08
The working bees to combat climate change.

Olga Lucia Quintero Montoya

Universidad EAFIT, Colombia

Abstract: Data Assimilation (DA) is a Bayesian technique to acquire data (from several sensors) into a mathematical model for improving predictions in Large Scale Systems (LSS). AI itself plays a significant role in DA for dimensionality reduction, finding missing data and spatial-temporary variations. To Combat Climate Change (C3) in Colombia we should design low-cost instrumentation systems powered by AI for in situ and remote sensing measurements, aiming to validate LSS and satellite devices calibration (FACSAT-Chiribiquete). Smart Payload (SP) should be onboard of an Unmanned System (UAV), this way, aeronautical design must be ruled by the fluid dynamics analysis of the payload´s air intake, the instruments physical-chemical principles and optical/infrared sensor. The manufacturing processes analysis (for composite material) guarantees the low-weight, good mechanical properties and a good quality/price ratio which are key to be efficient and sustainable in an underdeveloped country.

Keywords: data assimilation, remote sensing and in-situ sensing, fluid dynamics, materials and manufacturing, artificial intelligence

KS09
Urban flow predictions: understanding uncertainties to widen their application.

Clara García-Sánchez

Delft University of Technology, The Netherlands

Abstract: Nowadays, more than half of the world population lives in urban areas, while projections rise this number to 68% by 2050. Since most humans live in urban areas, the way we design those and embed them into the nature environment is very important for the health of future generations. In that sense, computational fluid dynamic (CFD) becomes a powerful tool to estimate wind flows and dispersion fields in the urban environment, however those predictions can be hindered by the multiple uncertainties present in microscale urban simulations. With our work we aim at improving our current understanding of the impact that diverse uncertainties may have in urban wind and dispersion. For that we explore different uncertainties, such as inflow and geometrical uncertainties. Inflow uncertainties are relevant in urban simulations due to the constant change in weather patterns, which locally derive in diverse wind layouts in urban canyons. Instead, geometrical uncertainties, that may be relevant for local flows, are relevant in the context of urban environments constantly developing to accommodate larger populations. The way we place urban fabrics and details in our cities, such as vegetation or water surfaces, may affect local air quality levels or pedestrian comfort around our homes.

Keywords: computational fluid dynamics, urban microscale simulations, geometry reconstruction, dispersion, uncertainty quantification

KS10
Exergetic Attribute of Fuel Cells in Hydrogen Aviation Including UAVs.

Birol Kılkış

OSTIM Technical University, Türkiye

Abstract: Main objective of this research is to avoid the release of water vapor from the fuel cells to the atmosphere. In hydrogen aircraft water may be stored or even used. But in UAVs it needs to be discharged to the atmosphere. Water vapor has an intricate effect for global warming. Increased water vapor in the atmosphere amplifies the warming caused by other greenhouse gases. Water vapor convectively injected into the mid-latitude lowermost stratosphere could affect stratospheric ozone. The associated potential ozone loss process requires low temperatures together with elevated water vapor mixing ratios that extensive UAV traffic may trigger.

Keywords: hydrogen aircraft, UAV, fuel cell, climate crisis, water vapor

KS11
Exploring the Future of Unmanned Aircraft Applications and Flight Safety.

Rikard Tyllström

Lund university School of Aviation, Sweden

Abstract: The future of Unmanned Aircraft Applications promises remarkable advancements and innovations if accompanied by a steadfast commitment to ensuring flight safety. Advancements in automation and artificial intelligence are set to revolutionize flight safety. Intelligent systems with machine learning algorithms will enhance real-time risk assessment and enable proactive decision-making. AI-driven predictive maintenance will detect potential failures in aircraft components, reducing downtime and minimizing the risk of in-flight emergencies. Additionally, improved communication systems and advanced data analytics will facilitate comprehensive situational awareness and precise air traffic management, mitigating congestion and enhancing overall safety. Emerging technologies such as unmanned aircraft systems and urban air mobility present new challenges for flight safety. Regulatory frameworks will need to adapt to ensure the safe integration of these aircraft into existing airspace. Increased connectivity and data-sharing among stakeholders have the potential to foster a collaborative safety culture. Enhanced training programs and simulations should enable remote pilots and air traffic controllers to handle complex situations effectively. The future of aviation holds tremendous potential for improving flight safety through technological innovation, adaptive regulations, and a collective commitment to excellence.

Keywords: aviation, innovation, flight safety, sustainability, interdisciplinary

ISS01
Hydrogen powered UAVs.

Hüseyin Devrim

TEKSIS İleri Teknolojiler, Türkiye

Abstract: The aim of this study is to examine the potential utilization of hydrogen energy in the aviation sector. Nowadays, the aviation industry is actively seeking environmentally friendly and sustainable energy sources to meet its ever-growing energy demands. In this context, hydrogen energy stands out as an alternative solution for aviation. It is discussed how hydrogen can be used in the aviation sector and the potential benefits it can offer to the industry. The high energy density, lightweight nature, and renewable characteristics of hydrogen are key factors that enable its utilization in aviation. Hydrogen fuel cells provide a clean energy source that can be used to generate electric power for aircraft. Furthermore, this abstract addresses the potential of hydrogen-powered UAVs (Unmanned Aerial Vehicles). Hydrogen-powered UAVs have emerged as an innovative field within the aviation sector. These vehicles can offer long flight durations, high energy efficiency, and environmentally friendly operations through hydrogen fuel cells. The lightweight and high energy density of hydrogen can enhance the performance of UAVs, enabling longer ranges and increased payload capacities. The utilization of hydrogen-powered UAVs can provide significant advantages, especially in areas such as remote sensing, surveillance, search and rescue, and logistics. Moreover, hydrogen-powered UAVs can reduce environmental impacts by emitting less carbon compared to traditional fossil fuel-powered UAVs.

Keywords: hydrogen, UAV, aviation, fuel cells, range increment

ISS02
Air Mobility Initiative U-Space (AMIUS) - Together for secure UAM operations in U-space.

Mona Moren

Airbus Urban Mobility (AUM), Germany

Abstract: Air Mobility Initiative (AMI) is a Bavarian funded program, with the focus towards the development and flight testing of an Air Mobility ECO System. It explores new solutions using digital U-space services, ensuring safe operations in a shared airspace. AUM is leading the AMIUS project. The challenges of this ongoing project are two-fold. The first one is to open up the urban airspace by applying U-space, using digital U-space services. The second challenge is to integrate the U-space within the complex and controlled airspace environment of Ingolstadt-Manching. The aim is to design and build an airspace operating under digital services, which can be used as a blueprint for future U-space deployments.

Keywords: aviation, air mobility, airspace control, urban airspace, U-space

ISS03
Design considerations for tethered unmanned air systems.

Ahmet Nezir Ertürk

Otonom Teknoloji, Türkiye

Abstract: Unmanned air systems have a grooving number of types for different problems and environments. Tethered air systems are connected to the ground or base platform using a special cable, called tether cable. This cable provides mechanical strength, unlimited power and uninterruptable high-speed communications between the ground and air segments. Although the mobility of the tethered air systems are totally different than the conventional systems, the tethered air systems have advantages for long flight endurance, operation in harsh environment, operation in GNSS denied environment and more. In this session, modern design considerations will be reviewed for multi rotor tethered systems and lighter than air platforms, namely aerostats. The design considerations will include the power electronics and communications for tethered applications, advanced materials for air platform and the tether cable, usage from mobile platforms (including unmanned platforms at land and sea), reducing crew workload for ground segment, and effects of advanced mission payloads.

Keywords: tethered aerostat, tethered drone, power electronics, tethered communications, lighter than air

ISS04
Modern GIS trends.

Barış Uz

ESRI Türkiye, Türkiye

Abstract: Geographic approach provides a framework for addressing challenges of our world which is a complex and highly interdependent ecosystem. The World we live in is rapidly changing and evolving while being increasingly dominated by human activities. The central problem is not the individual challenges but lack of understanding. Lack of understanding results in failure to collaborate which needs to be addressed immediately. The Geographic Approach, together with Mapping, are powerful means for creating the understanding, exploring alternatives, finding solutions and reaching agreement upon understanding. We will discuss some trends in geospatial technologies and how they help us address challenges of today's world with some real-world examples.

Keywords: geospatial technologies, information technology, digital twins, building information model, geographical information system

ISS05
Preliminary design of a solar-powered UAV.

Alessandro Borgia

Team Icarus PoliTO, Italy

Abstract: The Record Aircraft (RA) project, within the Team Icarus of the Polytechnic University of Turin, aims to design and build a solar-powered UAV. The purpose of this paper is to outline the steps that led to the preliminary definition of the aircraft. The main challenge is to achieve self-sustaining energy during flight using solar cells installed on wing and tail horizontal surfaces. Within the same context of efficiency, accurate aerodynamic sizing is required to minimize the power needed to maintain the aircraft in flight. The choice was made for an unconventional architecture, consisting of three fuselages and two vertical tails, to maximize the number of solar cells on the tail and ensure greater structural rigidity for the wing, given its considerable wingspan and aspect ratio. This architecture proves to be an excellent demonstrator in the field of UAVs for remote monitoring and zero-emission surveillance, providing significant advantages for missions characterized by long flight periods. As efficiency is the fundamental requirement of the entire project, it is necessary that all onboard systems have adequate performance for the purpose.

Keywords: preliminary design, unconventional design, solar powered, high efficiency systems, Autonomous UAV

ISS06
GNSS Architectures for high dynamics navigation.

Miguel Ángel Gómez López

National Institute of Aerospace Technology (INTA), Spain

Abstract: Global Navigation Satellite Systems (GNSS) have revolutionized navigation across various domains, but their performance in high-dynamics scenarios remains a challenge. This has a renewed interest due to the events on Ukraine war. This session presents a comprehensive analysis of GNSS architectures specifically designed to address the unique requirements of high dynamics navigation. The limitations of traditional GNSS architectures in high-dynamics scenarios are discussed, including signal degradation, and receiver tracking issues. Advanced GNSS architectures that overcome these challenges and enhance positioning accuracy, reliability, and continuity are presented. Integration of GNSS with other sensors, such as inertial measurement units (IMUs), is also discussed.

Keywords: navigation, high-dynamics scenarios, GNSS architecture, inertial measurement units

ISS07
Fast-time large-scale simulations for airspace capacity assessment.

Milan Rollo

AgentFly Technologies, Czechia

Abstract: Various drone applications have been deployed to real-world operations in recent years. As the use of drones increases in future years, unmanned traffic in cities will grow. There is a need to study the behavior of a large number of drones in shared airspace and understand the limits, restrictions, and capacity of the drone airspace. Limits and restrictions related to drone operations differ from manned aviation. In this presentation, various views on drone operations will be summarized. The presentation aims at the assessment of airspace capacity using fast-time simulations. It focuses on the organization of the airspace to fit in a maximum number of flights with respect to the environment and restrictions. Metrics and their relationship to capacity will be discussed, including various types of restrictions and how they impact the complexity of trajectories, efficiency, and capacity. Simple scenarios are used to demonstrate elementary principles. Complex scenarios modeling mimicking future traffic over real-world cities were designed. Traffic consists of various types, e.g., blood banking, medical and pharma delivery, EAD drones, and industrial inspections. Environment design includes no-flight zones related to restricted areas (e.g., historical areas in city centers) and manned traffic (zones related to airport runways to ensure safe operations of manned and unmanned traffic). Corridors across the no-flight zone are introduced to help optimize drone traffic near airports. The nominal composition of the traffic is iteratively increased and simulated to reach the limits of the airspace capacity.

Keywords: drone applications, unmanned traffic, drone airspace, airspace capacity, drone operations

ISS08
Revolutionizing Logistics for a Sustainable Future: Aerit's Journey to Create Global Drone Delivery Networks.

Alexander Perrien

Aerit, Sweden

Abstract: Drone delivery and autonomous logistics is something that is often seen as a part of a science fiction future. Recent technological and regulatory developments have now cleared the path to enabling a significantly more sustainable existence for communities around the world. But what does that journey actually look like?

Keywords: autonomous vehicles, drone delivery, regulations, unmanned vehicles, logistics

ISS09
The Sustainable Urban Mobility Indicators (SUMI) Framework.

Anna Palaiologk

Future Needs Management Consulting Ltd., Greece

Abstract: The Sustainable Urban Mobility Indicators (SUMI) Framework is a valuable tool for cities and local authorities to evaluate their mobility system, as it provides a comprehensive set of practical indicators. However, it is important to note that the framework does not include Urban Air Mobility (UAM) or the use of Unmanned Air Vehicles (UAVs) as a mean of transportation. This is where our research comes in. Our team has developed the Sustainable Urban Air Mobility Indicators (SUAMI) Framework to act as an addition to the SUMI Framework, specifically for UAVs, through the SAFIR-Med project. Our goal is to enable a faster acceptance and operationalization of UAM indicators for impact assessment, increasing their applicability and usability at the same time. Our research aims to bridge this gap by focusing on the socioeconomic dimensions of UAM. While our primary focus is on medical applications such as medical package deliveries and passenger transportation for patients or medical staff, our framework is applicable to all types of UAM activities. In summary, our SUAMI Framework is designed to help cities and local authorities make informed decisions about UAM implementation in their respective areas. It aims to be a practical and user-friendly tool that complements the SUMI Framework. By considering the technical and socioeconomic aspects of UAM and UAVs, we hope to provide a more holistic approach to performance assessment.

Keywords: sustainable urban mobility indicators framework, urban air mobility, unmanned air vehicles, sustainable urban air mobility indicators framework

001
Parametric Approach to Initial Weight Determination at Preliminary Design of a Quadrotor Cargo UAV.

Fikret Kamil Corbaci[1] and Yunus Emre Dogan[2]

[1]*STM A.S., Production Department, Ankara, Turkey*
[2]*Ankara Yildirim Beyazit University, Mechanical Engineering Department, Ankara, Turkey*

Abstract: Recently, unmanned aerial vehicles are systems that can successfully fulfill many missions in commercial fields with their wide range of payload capacities, different performance features and low operating costs. One of the areas that has become a trend in the use of UAVs is cargo transportation. As developed unmanned aerial vehicles in this area have given satisfied results, the design approach at this area gained importance. The main objective of this study is to establish a parametric design methodology to initial weight determination of a quadrotor UAV to be used to carry light weighted urgent payload among close locations. In this study, after identifying the components that meet the mission requirements, main design parameters (masses of motor, propeller, frame etc.) are determined and the relationships among these parameters were correlated each others. By using these results, the iteration number and design duration are reduced.

Keywords: unmanned aerial vehicle (UAV), cargo, parametric design, light weighted urgent payload, cargo transportation, quadrotor

002
Comparative Analysis of AI-Supported Drone Operations: Evaluating Critical Aspects among Pilot Groups.

Omar Alharasees and Utku Kale

[1]*Budapest University of Technology and Economics, Hungary*

Abstract: The integration of artificial intelligence (AI) into Drone operations has advanced the field, enhancing autonomy. However, evaluating critical aspects remains a challenge. This study proposes a combination of the "Observe-Orient-Decide-Act (OODA)" loop and the "Analytic Hierarchy Process (AHP)" to evaluate AI-supported Drone systems. The integrated approach assesses perception, decision-making, and adaptation. A comparative analysis of AHP results among different pilot groups, specifically experienced and less experienced pilots, reveals areas for improvement and guides technological development. The combined approach offers a comprehensive evaluation method for AI-supported Drone operations, focusing on pilot group comparison. This research contributes to understanding the current and future state of AI-Drone operations, informing advancements in the field.

Keywords: AHP, drones, OODA loop, human factor, safety, accidents