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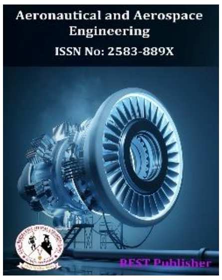

Autonomous Drones and Their Applications in Various Industries Using COPRAS Method

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Abstract. *Autonomous drones, also known as unmanned aerial vehicles (UAVs), have gained significant attention due to their potential applications across various industries. This paper explores the current state and future prospects of autonomous drones in industries such as agriculture, construction, logistics, and surveillance. The analysis covers the benefits and challenges of using autonomous drones, including increased efficiency, cost-effectiveness, and improved safety. Additionally, the paper discusses the regulatory framework and technological advancements driving the adoption of autonomous drones. The significance of researching autonomous drones and their applications in various industries lies in their potential to revolutionize several sectors. These drones offer numerous benefits, including increased efficiency, cost savings, improved safety, and access to remote or hazardous environments. Understanding their applications can lead to innovative solutions that enhance productivity and drive economic growth. Moreover, studying the regulatory and technological challenges associated with autonomous drones can help policymakers and industry leaders develop frameworks that ensure safe and responsible integration into existing infrastructure. COPRAS is a commonly used approach in Multi-Criteria Decision Making (MCDM). It determines the best solution ratio by comparing each alternative to a reference alternative, which is considered the best. However, this approach has its own set of decision-making challenges. Researchers have explored various problem-solving techniques to address these issues. From the result Mining is got the first rank whereas is Security is having the lowest rank.*

Keywords: *Small autonomous drones, agriculture, Silicon Valley drone industry, micro, mini, and large drones.*

1. INTRODUCTION

Small autonomous drones represent a pivotal advancement in science and technology, shaping the future of various industries. Their compact size and autonomous capabilities enable them to navigate complex environments with precision, offering applications in areas such as surveillance, agriculture, and disaster response. These drones are equipped with advanced sensors and AI algorithms, allowing them to perform tasks efficiently and autonomously.[1] Drones are increasingly used in manufacturing, offering significant opportunities for research and practical application. These unmanned aerial vehicles can streamline inventory management, monitor production processes, and enhance safety by accessing hard-to-reach areas. Research in this area can focus on optimizing drone use for inventory tracking, process monitoring, and maintenance tasks. Practically, industries can integrate drones into their operations to improve efficiency and safety, highlighting the need for research to address technical, regulatory, and operational challenges for successful implementation in manufacturing environments [2] Drones are increasingly utilized in emerging economies offering innovative solutions across various sectors. In agriculture, drones are used for crop monitoring and spraying, enhancing productivity and reducing manual labor. In disaster management, drones provide aerial surveys for faster response and recovery efforts. Additionally, in infrastructure development, drones assist in mapping and inspection tasks. Understanding these applications in Malaysia can serve as a valuable case study for other emerging economies, highlighting the potential of drones to drive economic growth and improve quality of life.[3] Drones can be classified based on size, autonomy, and application, with categories such as micro, mini, and large drones. Their applications range from aerial photography to agriculture, delivery, and surveillance. Design challenges include maximizing flight time, improving payload capacity, and ensuring safety and regulatory compliance.[4] Drone technology encompasses various types, including fixed-wing, multi-rotor, and hybrid designs, each suited to different applications. Payloads can include cameras, sensors, and even delivery mechanisms. Frequency spectrum issues arise due to limited bandwidth for communication and control. Future developments focus on enhancing autonomy, payload capabilities, and regulatory frameworks for safe integration into airspace.[5] The construction industry is embracing digitalization through immersive technologies like virtual reality and drones. VR enables immersive project visualization, aiding in design review and stakeholder communication. Drones are used for site surveys, progress monitoring, and safety inspections. Integrating these technologies enhances efficiency, collaboration, and safety in construction projects.[6] The future of UAVs in ecology, as seen from the Silicon Valley drone industry, is promising. UAVs offer cost-effective and efficient solutions for environmental monitoring and conservation. They can collect high-resolution data over large areas, aiding in biodiversity assessments, habitat monitoring, and disaster response. Continued innovation and collaboration will drive further advancements in UAV applications for ecological research and conservation efforts. [7] Drone delivery using autonomous mobility presents an innovative solution to last-mile delivery challenges. By leveraging drones for short-distance transport, companies can achieve faster and more cost-effective delivery, especially in urban areas. Autonomous drones can navigate traffic and deliver packages directly to customers, offering a convenient and efficient alternative to traditional delivery methods.[8] Application-specific drone simulators have advanced significantly, offering realistic training environments for specific tasks such as search and rescue or agriculture. These simulators help operators practice in various scenarios, improving skills and decision-making. Challenges include simulating complex real-world conditions accurately and ensuring compatibility with evolving drone technologies. [9] Commercial drones have a profound societal impact, revolutionizing industries like agriculture, delivery, and filmmaking. They enhance efficiency, reduce costs, and improve safety. However, they also raise concerns about privacy, safety, and job displacement. Balancing these benefits and challenges is crucial for maximizing the positive impact of commercial drones on society.[11] A generic drone control platform for autonomous capture of cinema scenes offers a standardized framework for filmmakers to program drone flights for dynamic and cinematic shots. By automating flight paths, camera angles, and movements, filmmakers can focus on creative aspects, streamlining the production process and enhancing the quality of aerial footage for film and video production.[12] Public acceptance of drones is influenced by knowledge, attitudes, and practices regarding these technologies. Knowledge about drones' capabilities and regulations shapes perceptions. Attitudes toward drones are influenced by perceived benefits, such as improved services and economic opportunities, versus concerns about privacy, safety, and noise. Actual experiences and interactions with drones can also impact public acceptance, highlighting the importance of education, regulation, and transparent communication to address concerns and promote responsible drone use.[14]

2. MATERIALS AND METHODS

2.1. Alternative parameters: Agriculture, Construction, Logistics, Mining, Security

2.2. Agriculture: Agriculture is the practice of cultivating soil, producing crops, and raising livestock for food, fiber, and other products used to sustain life. It includes activities such as planting, harvesting, irrigation, and animal husbandry. Agriculture is essential for providing food security, supporting rural economies, and contributing to environmental sustainability.

2.3. Construction: Construction is the process of building or assembling infrastructure, typically involving the use of materials such as concrete, steel, and wood. It includes activities such as designing, planning, and constructing buildings, bridges, roads, and other structures. Construction also involves the management of projects, including budgeting, scheduling, and coordinating labor and materials.

2.4. Mining: Mining is the process of extracting valuable minerals or other geological materials from the earth. It involves the exploration, extraction, and processing of minerals, metals, and fossil fuels. Mining can take place on the surface or underground and typically involves the use of heavy machinery and equipment. Mining is essential for the production of many goods and materials used in various industries, including construction, manufacturing, and energy production.

2.5. Security: Security refers to the measures taken to protect people, assets, and information from threats such as theft, vandalism, terrorism, and unauthorized access. Security measures can include physical security measures such as locks, fences, and security guards, as well as cyber security measures such as firewalls, antivirus software, and encryption. Security is important in a wide range of contexts, including national security, information security, and personal security.

2.6. Evaluation parameters: Payload Capacity (kg), Flight Time (minutes), Cost (USD), Safety rating (1-10)

2.7. Payload Capacity (kg): Payload capacity (kg) refers to the maximum weight of cargo or other materials that a vehicle, machine, or structure can safely carry or support. It is typically measured in kilograms and is an important consideration in industries such as transportation, construction, and aerospace. The payload capacity is the total weight of the cargo, passengers, equipment, and any other items that the vehicle or structure is designed to carry, excluding the weight of the vehicle or structure itself.

2.8. Flight Time (minutes): Flight time (minutes) refers to the duration for which an aircraft or drone can remain airborne on a single battery charge or fuel load. It is measured in minutes and is an important consideration for aircraft and drone operations, especially for tasks such as aerial photography, surveillance, and package delivery. Flight time is influenced by factors such as the aircraft's weight, battery or fuel capacity, and the efficiency of its propulsion system. Increasing flight time is a key goal in the development of drones and other unmanned aerial vehicles (UAVs).

2.9. Cost (USD): Cost (USD) refers to the amount of money required to purchase, produce, or maintain a product or service, measured in United States dollars (USD). Cost is a critical factor in decision-making for businesses and individuals, as it directly impacts profitability, budgeting, and financial planning.

2.10. Safety rating (1-10) L: Safety rating refers to a measure of the level of safety provided by a product, service, or system. It is often expressed as a numerical score or a rating scale, indicating the degree of safety assurance or the level of risk associated with using the product, service, or system. Safety ratings are commonly used in industries such as automotive, aviation, and consumer products to help consumers and stakeholders make informed decisions about safety. Higher safety ratings typically indicate a lower risk of accidents, injuries, or other safety-related incidents.

2.11. Method: COPRAS is a commonly used approach in Multi-Criteria Decision Making (MCDM). It determines the best solution ratio by comparing each alternative to a reference alternative, which is considered the best. However, this approach has its own set of decision-making challenges. Researchers have explored various problem-solving techniques to address these issues [15]. The COPRAS-G method entails establishing selection criteria, evaluating information related to these criteria, and devising techniques to assess how well the alternatives meet the criteria. It involves assessing the surrogate's overall performance. Decision analysis involves a Decision Maker (DM) examining a specific set of options and selecting one from many alternatives, usually based on competing criteria. Therefore, the COPRAS method, which was developed for assessing complexity proportionality, can be utilized [16]. In 1996, Lithuania introduced the COPRAS (Complex Proportion Evaluation) approach, which is used in construction economics, real estate, and management. A paper in this field assesses the risks associated with construction projects using various multi-objective assessment techniques. The assessment considers factors such as national interests, aspirations, and elements affecting construction efficiency and increases in real estate prices [17] The Complex Proportionality Assessment (COPRAS) method, like other Multi-Criteria Decision Making (MCDM) tools, is designed to evaluate alternatives based on multiple criteria. It prioritizes criterion weights, with the strategy of Worst-Best Solutions often being considered the best choice for assessing alternatives [18]. COPRAS is applied to address Multiple Criteria Decision Making (MCDM) issues where criteria weights and alternative performance ratings are absolute and determined using linguistic terms. A study compared the calculated criteria with the COBRAS approach to assess renovation strategies.[19] This study examines the objectives of enhancing the impact of the latest performance measures in TPM and COPRAS in ambiguous situations, particularly in multi-criteria decision-making. The approach utilizes the Decision-making Trial and Evaluation Laboratory (DEMATEL) method. The structure of the paper is as follows: Section 1 provides an overview of the problem and a literature review. Section 2 focuses on the COPRAS-G method and its literature review. Sections 3 and 4 outline the key concepts of the COPRAS-G methodology, highlighting its implementation using the proposed approach. This complex proportional assessment method utilizes numerical data within the framework of Grey Systems Theory. The COPRAS-G approach is based on Grey Systems Theory applications, real-world decision-making contexts, and time-based normative values [20] The COPRAS method is utilized to rank and select the most relevant social media platforms. Its applicability is proposed in assessing cumulative performance of alternatives based on important criteria, comparing possibilities, and fulfilling decision makers' wishes. COPRAS involve evaluating options against competing requirements, allowing for real-world application. Criteria are ambiguous and values cannot be stated numerically [21].

3. RESULTS AND DISCUSSION

TABLE 1. Autonomous drones and their applications in various industries

	Payload Capacity (kg)	Flight Time (minutes)	Cost (USD)	Safety Rating (1-10)
Agriculture	10	30	5000	8
Construction	20	40	8000	6
Logistics	5	20	4000	7
Mining	30	60	12000	9
Security	10	30	5000	10.00

Table 1 shows compare above values. Payload Capacity (kg): Mining has the highest payload capacity at 30 kg, followed by Construction at 20 kg. Agriculture, Security, and Logistics have similar payload capacities at 10 kg. Flight Time (minutes): Mining has the longest flight time at 60 minutes, followed by Construction at 40 minutes. Agriculture and Security have a flight time of 30 minutes, while Logistics has the shortest flight time at 20 minutes. Cost (USD): Mining is the most expensive at 12000 USD, followed by Construction at 8000 USD. Agriculture and Security have the same cost at 5000 USD, while Logistics is the least expensive at 4000 USD. Safety Rating (1-10): Security has the highest safety rating of 10.00, followed by Mining at 9. Agriculture and Logistics have similar safety ratings at 8 and 7 respectively, while Construction has the lowest safety rating at 6. These comparisons show that each industry's requirements and priorities are reflected in the specifications and characteristics of the autonomous drones used.

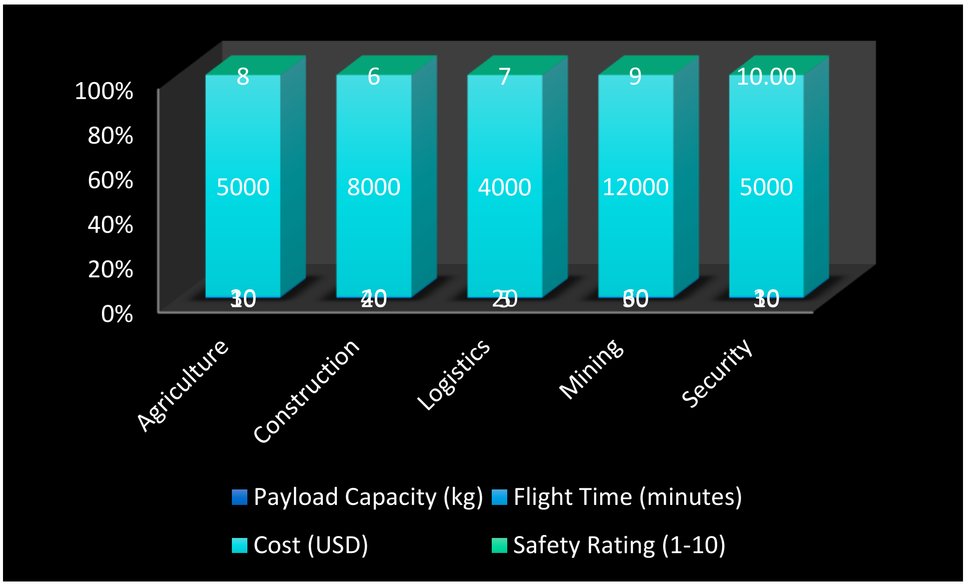

FIGURE 1. Autonomous drones and their applications in various industries

Figure 1 illustrate the graphical representation of Autonomous drones and their applications in various industries

TABLE 2. Normalized Data

Payload Capacity (kg)	Flight Time (minutes)	Cost (USD)	Safety Rating (1-10)
0.1333	0.2000	0.1471	0.2000
0.2667	0.2222	0.2353	0.1500
0.0667	0.1111	0.1176	0.1750
0.4000	0.3333	0.3529	0.2250
0.1333	0.1667	0.1471	0.2500

Table 2 shows explanation of normalized data. Payload Capacity (kg): This represents the weight capacity of the drone in kilograms. The values have been scaled to a range from 0 to 1, where 0 represents the lowest payload capacity and 1 represents the highest. For example, Mining has the highest payload capacity of 0.4, indicating that it has the highest payload capacity among the industries listed. Flight Time (minutes): This represents the duration for which the drone can remain airborne on a single charge. The values have been scaled to a range from 0 to 1, where 0 represents the shortest flight time and 1 represents the longest. For example, Mining has a flight time of 0.3333, indicating that it has the longest flight time among the industries listed. Cost (USD): This represents the cost of the drone in US dollars. The values have been scaled to a range from 0 to 1, where 0 represents the lowest cost and 1 represents the highest. For example, Mining has a cost of 0.3529, indicating that it is the most expensive among the industries listed. Safety Rating (1-10): This represents the safety rating of the drone on a scale from 1 to 10. The values have been scaled to a range from 0 to 1, where 0 represents the lowest safety rating and 1 represents the highest. For example, Security has a safety rating of 0.25, indicating that it has the highest safety rating among the industries listed.

TABLE 3. Weighted normalized decision matrix

Weighted normalized decision matrix			
0.03	0.05	0.04	0.05
0.07	0.06	0.06	0.04
0.02	0.03	0.03	0.04
0.10	0.08	0.09	0.06
0.03	0.04	0.04	0.06

Table 3 shows weighted normalized decision matrix .The weights and normalized scores in the matrix are used to calculate a weighted sum or weighted average for each alternative. This allows decision-makers to compare and rank the alternatives based on their overall performance, considering the relative importance of the criteria. To calculate the overall performance score for the first alternative, would multiply each criterion's score by its respective weight, and then sum the products: Overall Performance (Alternative1)=(0.02* Weight1)+(0.06* Weight2)+(0.06* Weight3)+(0.05* Weight4)

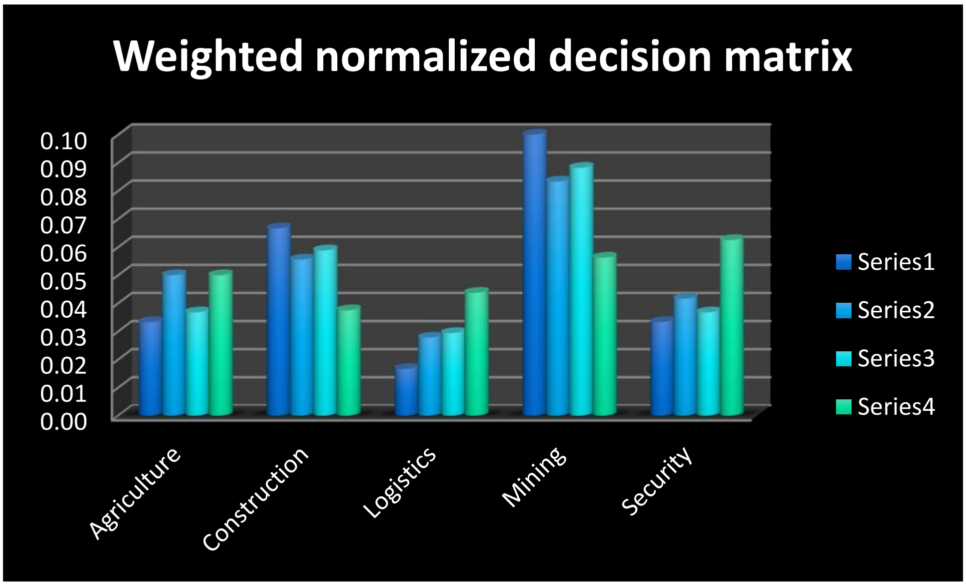

FIGURE 3.weighted normalized decision matrix

Figure 3 illustrate the graphical representation of weighted normalized decision matrix

TABLE 4. Bi, Ci, Min (Ci)/Ci

Bi	**Ci**	**Min(Ci)/Ci**
0.083	0.087	0.8432
0.122	0.096	0.7595
0.044	0.073	1.0000
0.183	0.144	0.5064
0.075	0.099	0.7370

Table 4 shows Bi,Ci, Min(ci\ci) , The Bi value is 0.083, the Ci value is 0.087, and Min(Ci)/Ci is approximately 08432. This means that the industries with Bi = 0.080 has a Ci value that is about 75.16% as good as the best-performing industries, which has the minimum Ci value. The Bi value is 0.122, the Ci value is 0.096, and Min(Ci)/Ci is approximately 0.7595. The industries with Bi = 0.122 is about 84.40% as good as the best industries. This pattern continues for the other rows, where the Min(Ci)/Ci values represent the relative performance of each industries compared to the best-performing one

TABLE 5. Final Result of Autonomous drones and their applications in various industries.

Qi	Ui	Rank
0.193	77.4409	3
0.221	88.6829	2
0.174	70.0129	4
0.249	100.0000	1
0.171	68.5562	5

Table 5 show compare the qi andui value, Qi (Normalized Payload Capacity): Mining has the highest normalized payload capacity (Qi) at 0.249, indicating it has the highest payload capacity among the industries listed. Construction has the second-highest payload capacity at 0.221, followed by Agriculture at 0.193. Logistics and Security have the lowest normalized payload capacities at 0.174 and 0.171 respectively. Ui (Normalized Safety Rating): Mining has the highest normalized safety rating (Ui) at 100.0000, indicating it has the highest safety rating among the industries listed. Construction has the second-highest safety rating at 88.6829, followed by Agriculture at 77.4409. Logistics and Security have the lowest normalized safety ratings at 70.0129 and 68.5562 respectively.

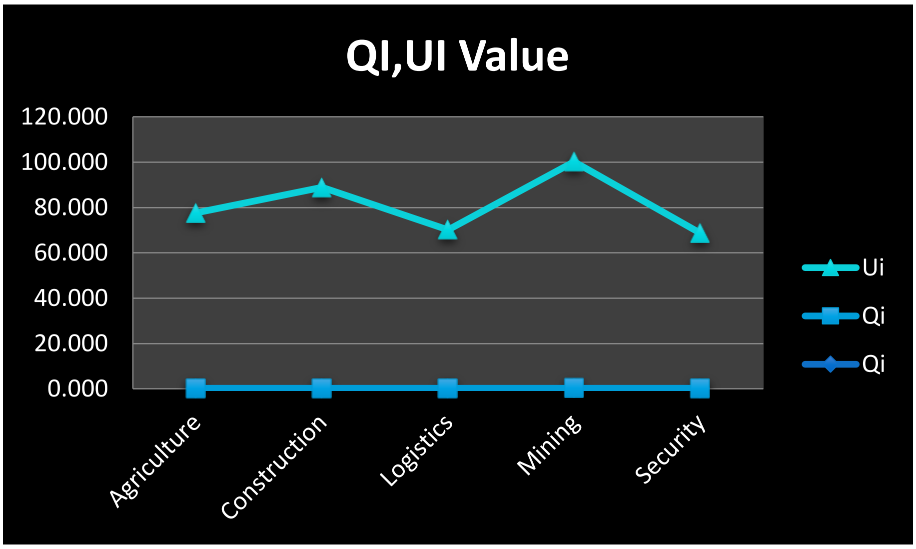

FIGURE 4. Qi, Ui Value

Figure 4 illustrate the graphical representation of Qi, Ui value.

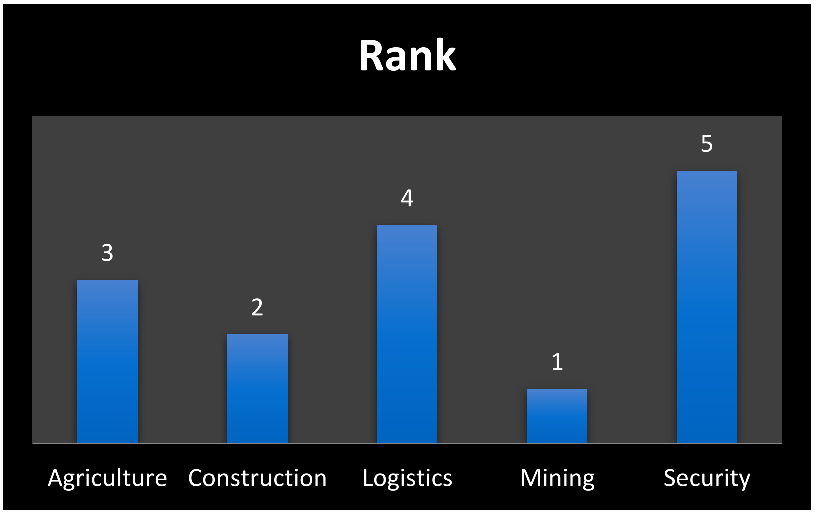

FIGURE 5. Rank

Figure 5 Shows ranking of Autonomous drones and their applications in various industries, mining is got the first rank whereas is Security is having the lowest rank.

4. CONCLUSION

Autonomous drones offer diverse applications across industries, each with specific needs. In agriculture, they provide efficient crop monitoring and spraying, enhancing productivity. Construction benefits from drones' ability to survey sites and monitor progress, improving safety and efficiency. Logistics sees improved delivery speed and cost-effectiveness through drone-based transport. Mining utilizes drones for remote site surveillance and mapping, enhancing operational efficiency and safety. Security benefits from drones' surveillance capabilities, improving monitoring and response times. These applications showcase the versatility and potential of autonomous drones in revolutionizing various industries, improving processes, and driving innovation.

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