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Bibliometric Analysis of Research Papers on Drones in the Mining Sector: A Documentary Review and Author Positioning

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Abstract

This research paper conducted a comprehensive review of documentaries related to the production and publication of research papers focusing on the study of drones in the mining sector. The proposed bibliometric analysis examined the critical characteristics of publications registered in the Scopus database between 2018 and 2022, identifying 121 relevant papers. The information obtained from the platform was systematically organized using tables and figures, allowing for categorization based on factors such as year of publication, country of origin, area of knowledge, and publication type. Following this description of characteristics, a qualitative analysis was performed to analyze the perspectives and positions of various authors on the topic. Notably, the research findings revealed that the United States had the highest scientific production of authors affiliated with institutions from that country, with 16 publications. Furthermore, the engineering field made the most significant contribution to the scholarly material on drones in the mining sector, with 54 published documents. Regarding publication type, journal articles were the most utilized format, comprising 60 documents from the total scientific production.

Keywords: *Drones, Mining Sector, Industry 4.0, Data Collection.*

1. Introduction

Given its significant contributions to economic growth and employment opportunities, mining is widely recognized as a highly sought-after and valuable endeavor for nations. As a crucial component of the Mining Sector, mining activities primarily involve the extraction of materials and minerals that serve as essential raw materials for various purposes, such as producing jewelry, construction materials, and generating indispensable energy resources.

While the economic significance of mining cannot be understated, it is crucial to acknowledge that it also poses considerable risks to both the well-being of its workforce and the surrounding environment. The constant exposure to soil variations inherent in mining operations can jeopardize the health and even the lives of the personnel involved. Consequently, considering technological advancements and the advent of novel tools, companies within the mining sector are continuously seeking alternatives to enhance data collection processes in terms of effectiveness, safety, and efficiency. The primary

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objective is to enable informed decision-making within minimal timeframes, exemplified by the utilization of drones.

A drone or unmanned aerial vehicle can be defined as follows:

These aerial devices, commonly called UAVs (Unmanned Aerial Vehicle) or drones, are autonomous aircraft operating without a crew onboard. They are designed to achieve controlled and sustainable flight and are powered by either electric or jet engines. Drones can be categorized into two primary groups based on their purpose: military and civilian applications. (Matías Ayma, 2020).

Drones serve various functions depending on the specific sector in which they are deployed. Their primary role entails capturing and gathering information with greater precision and detail. This is particularly valuable as drones can access areas that are challenging to reach through traditional methods. Additionally, traditional approaches incur high costs, primarily associated with acquiring high-resolution satellite images and employing human-crewed aircraft for photography. The existing cartography practices often lack cadastral purposes, further hampers such studies (Rojas Velásquez & Romero Carrillo, 2020). Considering these factors and pursuing the overarching objective, this research paper aims to outline the key characteristics of publications available in the Scopus database that are directly related to the use of drones in the mining sector. Moreover, the paper seeks to provide insights into the perspectives of authors affiliated with institutions worldwide from 2018 to 2022.

2. General Objective

To conduct a comprehensive bibliometric and bibliographic analysis to examine the evolution and advancement of research papers focusing on the potentials and opportunities presented by drones in the mining sector. Specifically, the analysis will cover the period from 2018 to 2022

3. Methodology

This research article employs a mixed-method approach, combining quantitative and qualitative methods to investigate the subject matter.

The quantitative aspect of the study involves a bibliometric analysis of the selected information from Scopus, focusing on the scientific production related to the exploration of drones in the mining sector. This approach allows for a comprehensive quantitative examination of the research output in this field.

In addition, a qualitative analysis is conducted from a bibliographic perspective, wherein selected research papers within the domain mentioned above are examined. This qualitative approach provides insights into the perspectives and positions of different authors on the proposed topic.

Notably, the entire search process was conducted exclusively through the Scopus platform, adhering to the parameters illustrated in Figure 1.

3.1 Methodological design

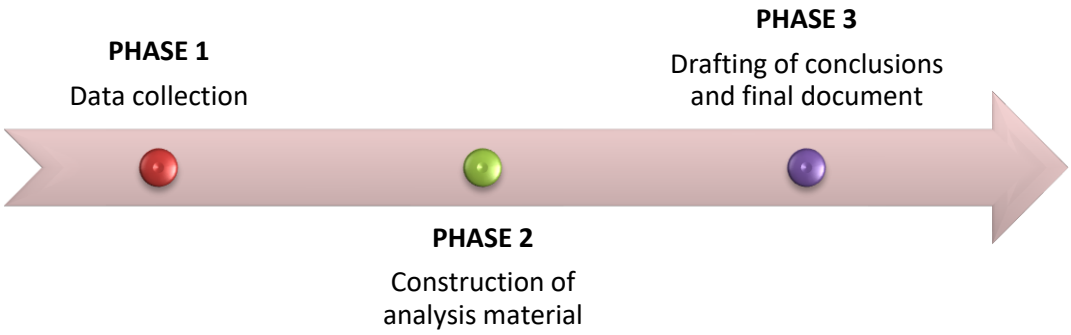

Figure 1. Methodological design

Source: Own elaboration

3.1.1 Phase 1: Data Collection

Data collection was conducted using the search tool on the Scopus website, applying specific filters to obtain a total of 121 publications. The filters utilized were as follows:

✓ Keywords: "possibilities" AND "of" AND "drones" AND "in" AND "mining" AND "sector."

✓ Inclusion criteria: Published papers that address variables relevant to the exploration of possibilities associated with drones in the mining sector

✓ Temporal scope: Limited to the years 2018-2022

✓ Country limitation: No restrictions were imposed based on country of origin

✓ Field of knowledge: No limitations were imposed based on specific areas of knowledge

✓ Publication type: No distinctions were made in terms of publication types considered

These filters were applied to ensure a comprehensive collection of relevant publications for further analysis.

3.1.2 Phase 2: Drafting of Conclusions and Final Document.

The data collected from Scopus in the preceding phase is systematically organized and classified using visual aids such as graphs, figures, and tables. The classification is carried out based on the following categories:

✓ Co-occurrence of words: Identifying the frequency and patterns of word combinations or terms commonly appearing in the collected publications.

✓ Year of publication: Categorizing the publications based on the specific years they were published provides insights into temporal trends and developments.

✓ Country of origin: Analyzing and categorizing the publications according to the countries from which they originated, facilitating an understanding of the geographical distribution of research contributions.

✓ Area of knowledge: Classifying the publications based on the specific fields or areas of knowledge to which they belong, enabling an examination of the interdisciplinary nature or concentration of research in particular domains.

✓ Type of publication: Categorizing the publications based on their format or type, such as journal articles, conference papers, or book chapters, allowing for an assessment of the dissemination channels and scholarly outputs.

This organizational framework using graphs, figures, and tables enhances the clarity and comprehensibility of the collected information, enabling a structured and systematic dataset analysis.

3.1.3 Phase 3: Drafting of Conclusions and Final Document.

The subsequent phase involves analyzing the obtained results, leading to the formulation of conclusions, and subsequently generating the final document. This process entails thoroughly examining the findings and drawing meaningful insights from the collected data, ultimately producing a comprehensive and conclusive research document.

4. Results

4.1 Co-occurrence of Words

Figure 2 shows the co-occurrence of keywords found in the publications identified in the Scopus database.

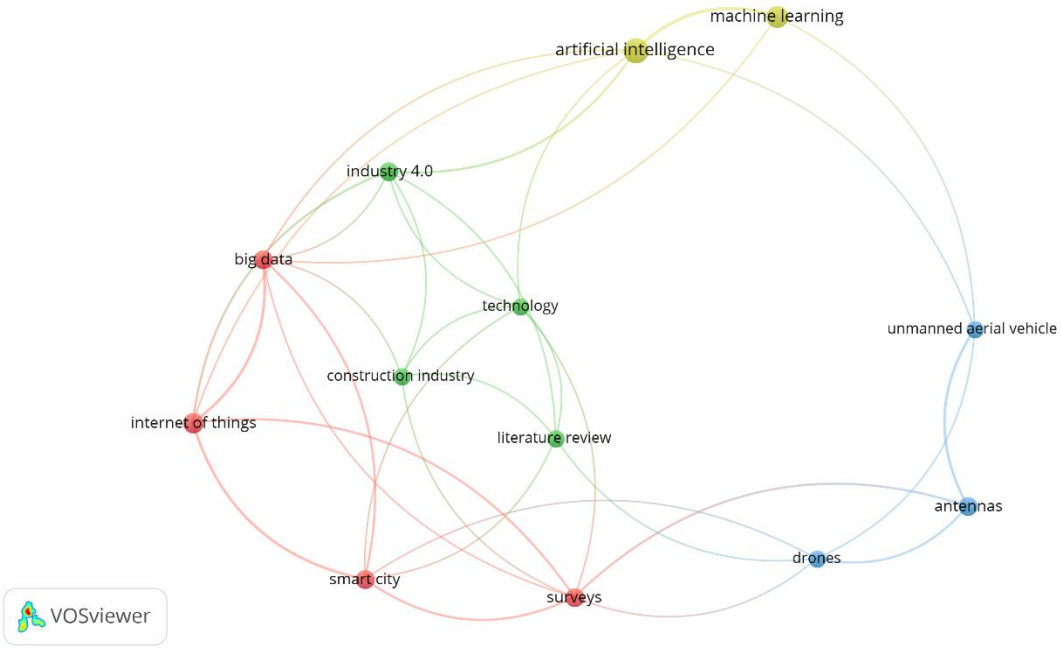

Figure 2. Co-occurrence of words

Source: Own elaboration (2023) based on data exported from Scopus.

The data depicted in Figure 2, extracted from Scopus, illustrates the variables and their interrelationships, which are elaborated upon below.

The advent of Industry 4.0, also referred to as the fourth industrial revolution, is characterized by the synergistic integration of advanced technologies such as artificial intelligence, the internet of things, and drones. These cutting-edge technologies enable the efficient management of substantial volumes of data, often in autonomous or semi-autonomous manners.

The emergence of this new industrial paradigm has undoubtedly facilitated the successful execution of projects and the production of goods at reduced costs, consequently enhancing the profitability of companies. Furthermore, implementing these advanced

technologies has significantly streamlined decision-making processes in various large-scale projects, mitigating the risks of failures or catastrophes that could otherwise jeopardize operational efficiency or impact the workforce.

4.2 Distribution of Scientific Production by Year of Publication.

Figure 3 shows the distribution of scientific production by year of publication.

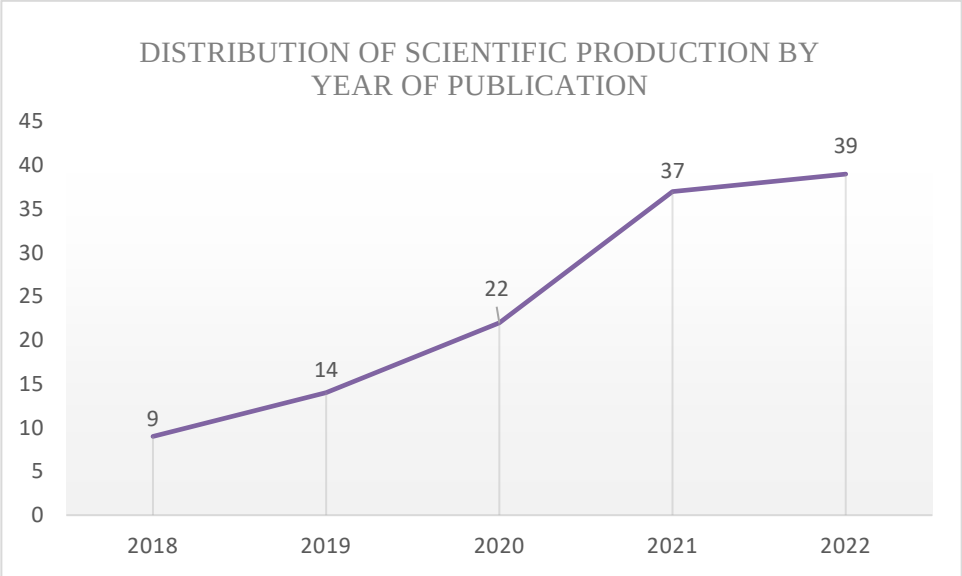

Figure 3. Distribution of scientific production by year of publication.

Source: Own elaboration (2023) based on data exported from Scopus.

Figure 3 presents the scientific production pertaining to the variables associated with the possibilities of utilizing drones in the mining sector between 2018 and 2022. This analysis yielded a total of 121 documents available in the Scopus database. Notably, significant changes were observed over this time frame. In 2018, there were nine publications, and this number varied in subsequent years. The year 2019 witnessed the publication of 14 texts, which increased to 22 in 2020. Subsequently, in 2021, there was a further surge with 37 published documents, followed by a slight increase to 39 publications in 2022.

Of particular significance from 2022 onwards is the inclusion of the conference proceedings titled "The specific design of flood monitoring of the Rozna i uranium mine, Czech Republic," authored by Hummel, Jaroš, and Vokurka (2022). This work addresses the flooding of the last uranium mine in Central Europe, where uranium ore extraction continued until 2017. The proceedings propose various approaches for continuously monitoring the mine's water level, enabling comparisons with available data. These approaches include a periodic sampling of mine water for physicochemical parameter measurement and continuous monitoring of hydrochemical parameters using fully solid-state sensors specifically designed for challenging mining conditions or using UNEXMIN autonomous underwater drones (Hummel, Jaroš, & Vokurka, 2022).

4.3 Distribution of Scientific Production by Country of Origin.

Figure 4 shows the distribution of scientific production according to the nationality of the authors.

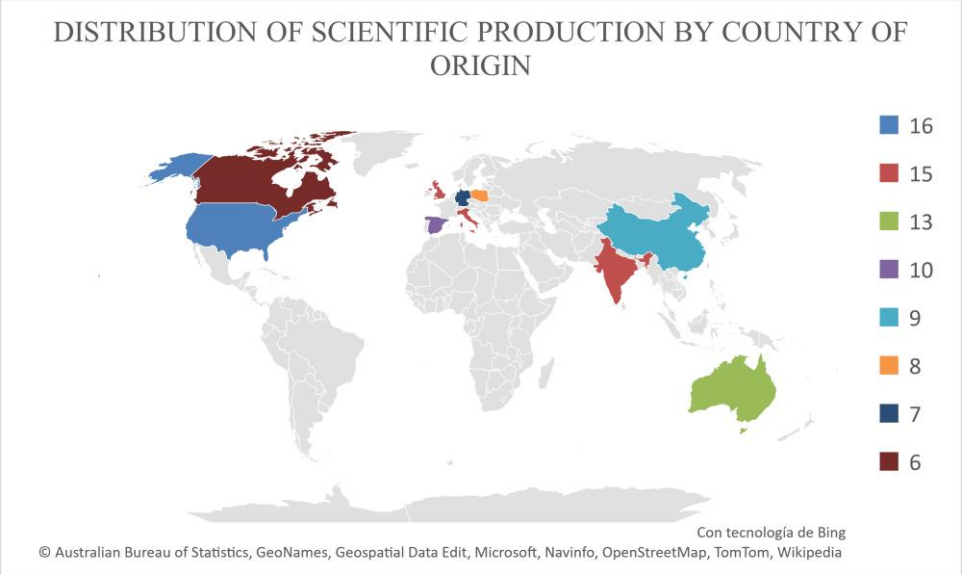

Figure 4. Distribution of scientific production by country of origin.

Source: Own elaboration (2023) based on data provided by Scopus.

In investigating the possibilities surrounding the utilization of drones in the mining sector, the United States emerges as the leader in terms of published papers, with 16 records found within the Scopus database during the period spanning 2018 to 2022. Following closely are India and Italy, both with 15 papers each.

One notable contribution to the field is the conference proceedings titled "Integrated environmental monitoring system in the Reclamation of a large open pit coal mine," authored by M.A. and T.A. (2018). This study focuses on addressing the issue of environmental pollution across all stages of a large-scale coal mining operation, particularly during the closure and reclamation phase following the cessation of mining activities. The paper examines the components that affect the atmosphere, utilizing drones as a tool for comparison against results obtained through conventional methodologies. The study concludes by outlining the advantages of this approach and offering recommendations on the specific equipment used, as well as methodological approaches for organizing an integrated monitoring system, including flight schemes and altitudes (M.A. & T.A., 2018).

It is worth noting that scientific publications often involve collaborations between various private and/or public institutions from different countries. Consequently, a single publication may be associated with multiple authors of diverse nationalities and correspondingly linked to more than one country simultaneously. This aspect contributes to each country's overall count of articles or publications. Figure 5 provides a detailed representation of the collaborative efforts undertaken by multiple nations in this domain.

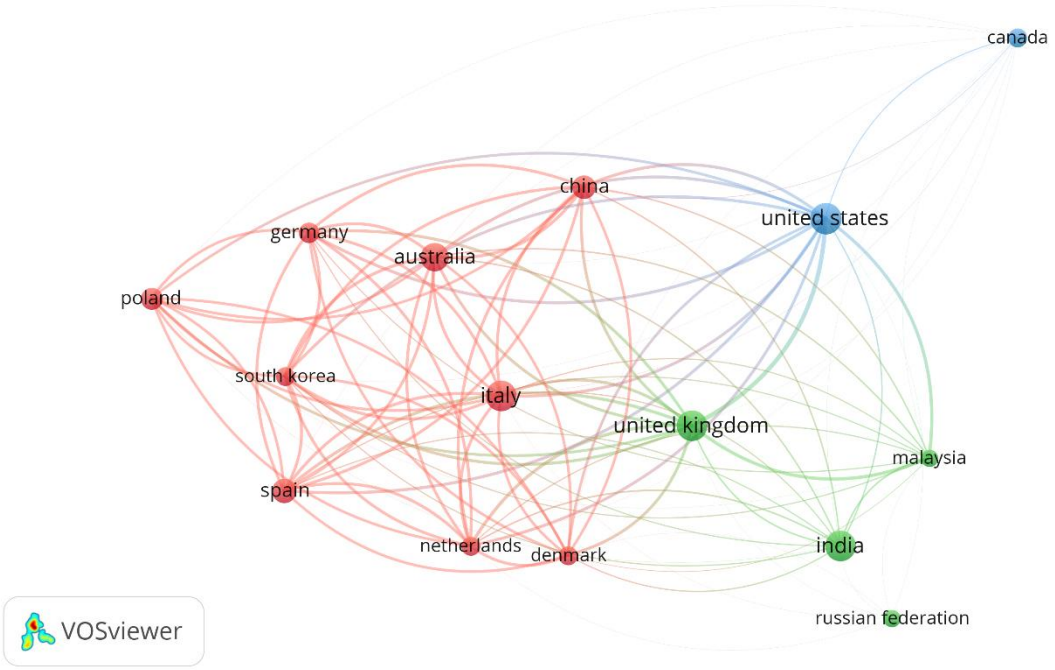

Figure 5. Co-citations between countries.

Source: Own elaboration (2023) based on data provided by Scopus.

Figure 5 illustrates the categorization of research based on the collaborative efforts of authors affiliated with various international institutions. Notably, significant contributions are observed from authors associated with institutions in countries such as the United States, Canada, and the United Kingdom, and other nations spanning different regions, including South Korea, Australia, Spain, and Russia.

4.4 Distribution of Scientific Production by Area of Knowledge

Figure 6 shows the distribution of scientific publications according to the area of knowledge through which the different research methodologies are implemented.

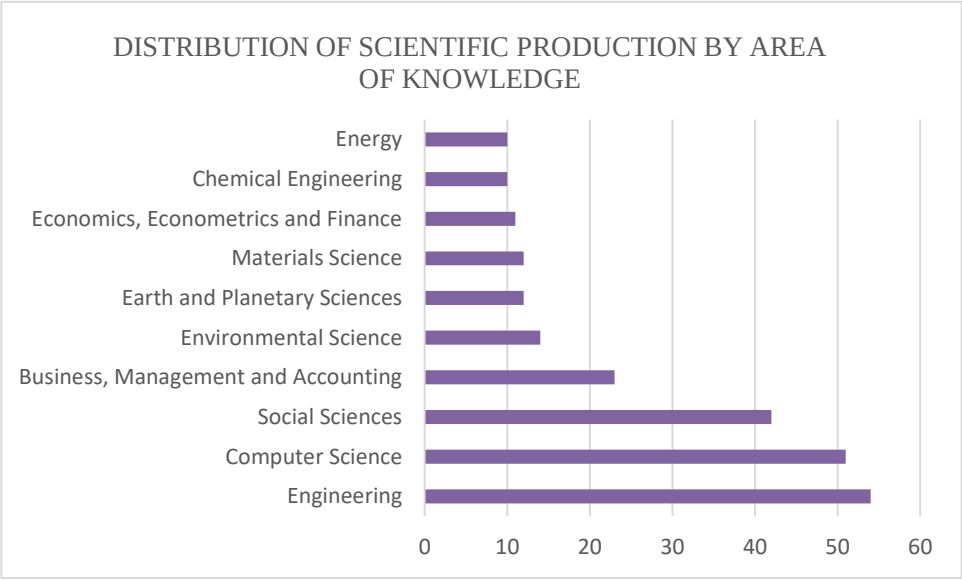

Figure 6. Distribution of scientific production by area of knowledge.

Source: Own elaboration (2023); based on data provided by Scopus.

Given the nature of these variables and their potential impact on entire communities, it is unsurprising that most publications from the Scopus database focus on these variables come from the engineering field, representing the highest proportion of published documents. Other disciplines, such as computer science and social sciences, have also contributed to studying these variables, with 51 and 42 papers published, respectively.

Figure 6 demonstrates the relevance of these variables across various areas of knowledge, as they can be examined from multiple perspectives that emphasize collecting large-scale data reliably and securely. This comprehensive approach aims to contribute to effective decision-making processes for addressing and preventing environmental, social, and related issues.

4.5 Type of Publication

The following graph shows the distribution of the bibliographic findings according to the type of publication made by each of the authors found in Scopus.

Figure 7. Type of publication.

Source: Own elaboration (2023) based on data provided by Scopus.

Figure 7 depicts the predominant types of publications in the field of Drone Possibilities in the Mining Sector. Journal articles are the most common publication type, accounting for 60 documents. Following are books, with 24 papers, and conference proceedings, with 15 publications.

In the research article "Drone-based identification of erosional processes in restored open-pit mining areas" (Alcañiz et al., 2022), the authors highlight the valuable role of unmanned aerial systems, or drones, in managing open-pit mining operations and facilitating ecological restoration activities. The article presents a method that utilizes remote sensing of drone images to identify water erosion processes in active quarries, even in the absence of pre-existing images or maps for comparison. Through extensive data collection from captured images, erosion factors specific to this type of mining could be swiftly and accurately identified. Consequently, the presented method proves to be a practical landscape modeling tool, allowing for the characterization of the evolution of restoration efforts in open pit mining areas using affordable and non-invasive materials.

5. Conclusions

Based on the bibliometric analysis conducted in this research, it can be concluded that the United States has the highest number of published records related to the Possibilities of Drones in the Mining Sector, with 16 publications in the Scopus database from 2018 to 2022. The field of engineering made the most outstanding contribution with 54 texts.

The significant number of documents on this topic indicates the viability of implementing drones in the mining sector. Drones offer benefits throughout the mining process, from exploration to closure and post-closure phases, as Arias Henao and Carreño Montero (2020) highlighted.

Furthermore, using drones brings about various positive impacts, including cost savings, enhanced data quality, and improved efficiency. By capturing visual and topographic data, drones assist in identifying geotechnical and mineral-rich areas, leading to additional revenue generation. They also enable the collection of high-resolution data and images, which can be used for historical record-keeping and future planning. Moreover, drones facilitate efficient communication with stakeholders by providing real-time updates on ongoing operations and allowing for rapid data collection over large areas (Arias Henao & Carreño Montero, 2020).

While the benefits of using drones in the mining sector are evident, it is crucial to acknowledge that their effective utilization requires a combination of technologies and trained personnel for programming. Therefore, it is encouraged that scientific communities, irrespective of their disciplinary background, actively study these variables, aiming to provide more alternatives and contribute to research on topics of general interest. Additionally, transparency in ensuring access to this type of information for everyone remains a vital objective (Arias Henao & Carreño Montero, 2020).

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