

Data Mining and Visualization of Space Technology Research Trends in the Arab World

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Abstract— Space exploration has become a crucial field in recent years, with many countries investing heavily in research and development to enhance their capabilities. Nevertheless, there has been a lack of research on the trends and advancements in aerospace research in the Arab world. This study aims to address this gap by conducting a bibliometric analysis of scientific publications using the Scopus database. The analyzed data covers the period from 1980 to 2022 and focuses on identifying the historical foundations, evolution, and emergence of space programs through citation, occurrence, collaboration, and clustering. The United Arab Emirates is found to be the most active country in terms of publications, followed by Saudi Arabia and Egypt. The results indicate that the majority of the publications are centered on remote sensing and the use of optical systems in space exploration. This study provides valuable insights into technological innovation in the aerospace sector in the Arab world and highlights potential research directions for future studies.

Keywords— Data mining, Space exploration, Arab world, Bibliometric, VOSviewer

I. INTRODUCTION

Space exploration has gained significant attention in recent years as countries worldwide invest in research and development to enhance their capabilities in this field. The space exploration economy in 2019 was valued to more than 423 billion US dollars, encompasses a variety of activities related to researching, exploring, and utilizing space [1]. To assist governments and space community organizations with various aspects of space-related activities, including policy, legal, and technical capacity-building, the United Nations established 1958 the Office for Outer Space Affairs (UNOOSA) [2]. The UNOOSA assists developing nations in using space technology for the advancement of sustainable development through the execution of the "Space2030" Agenda [3], [4]. This encompasses utilizing satellite data and imagery for environmental monitoring, space-based communication, and remote sensing systems for resource management and planning. The ultimate goal is to create sustainable solutions for tackling problems like poverty, hunger, health, education, and climate change [5], [6].

The Arab world is among those countries that are investing in space technology and space programs to advance their presence in the space exploration field. In recent years, the Arab countries have been making significant developments in the space exploration technology field. According to a report by UNESCO [7] many Arabic countries like Saudi Arabia, Tunisia, United Arab Emirates (UAE), Morocco, and Algeria have been investing heavily in the development of new technologies and capabilities in this field. One of the key areas where Arab countries have made significant progress is in electronics and digitalization. Saudi Arabia and Tunisia are leading the way in this field, which allowed them to build

advanced capabilities in areas such as satellite communication, remote sensing, and navigation. The UAE has also been investing heavily in space technology, intending to become a major player in the global space industry. The country has launched several satellites and has plans to establish a human settlement on Mars within the next few decades. Algeria, Morocco, Jordan, Egypt, and Tunisia have made significant developments in the area of solar energy, with Morocco leading the hydropower field as they invested the development of new technologies to harness the power of the wind. Algeria, too, has been active in the field of renewable energy and space technology, with extensive research in the area of solar energy. The country is also investing in the development of new technologies for satellite communication and remote sensing.

Overall Arab countries have been making notable advancements in space technology and space exploration, and many of them have ambitious plans for the future based on their national programs. They are investing in new technologies and capabilities and are well on their way to becoming major players in the space industry exploration. In this context, led by the UAE [8], the Arab Space Cooperation Group was established in 2019 to promote cooperation and collaboration among Arab countries in exploring the space. The organization aims to advance the development and use of space technology for peaceful purposes such as satellite communication, remote sensing, and space science. Additionally, the group supports the training and development of Arab professionals in the space sector and promotes public awareness and education about space in the Arab world.

While the Arab world is making significant progress in the field of space technology research, there is a lack of research on the specific trends and developments of space exploration in the Arab world. To the best knowledge of the author, no study has been conducted on bibliometric analysis of space exploration in the Arab world. However, other bibliometric studies exist such as the work of Ahmed et al. [9] who used bibliometric analysis to investigate the research productivity in the Arab world between 1980 and 2020. Findings indicate that Arab countries show high numbers of publications and citations but are behind in academic-industry collaborations. The top major subject areas were physical sciences and life sciences. Other research used bibliometric analysis to evaluate research on the environment, [10], health [11], climate change [12], and more recently on COVID-19 [13]. This study aims to fill this gap by conducting a bibliometric analysis of scientific publications related to space exploration. The objectives include collecting records of published articles from Scopus and tracking the progress in space technology research.

The paper has been structured as follows: Section 2 provides an overview of existing research on space

exploration, Section 3 outlines the data and method used to analyze data and create visualizations, Section 4 presents and analyzes the findings, and Section 5 presents the conclusion.

II. SPACE EXPLORATION IN THE ARAB WORLD

The Arab world has made significant contributions to space exploration. The region has seen several historical milestones, including the first Arab astronaut, Prince Sultan ibn Salman Al Saud, who traveled into space in 1985, and Syrian astronaut Mohammad Faris who flew as part of a joint Syrian-Soviet mission in 1987. More recently, Hazza Ali Abdan Khalfan Al Mansouri of the UAE traveled to the International Space Station in 2019, and the UAE's "Hope" spacecraft which was successfully launched and arrived at Mars in 2021 [14]. In terms of specific areas of research, the Arab world has made significant progress in satellite technology. For example, the first Arabsat-1A was launched in 1985, and since then many other satellites were launched such as Inmarsat GX5, KhalifaSat, FalconEye, Shaheen Sat, EgtSat, Maroc-TUBSat, the SaudiSat-5A, and 5B, launched, etc [15].

The Arab world has been showing a growing trend toward developing domestic capabilities in space technology [16]–[18]. The United Arab Emirates established the Emirates Space Agency and invested in creating a domestic satellite manufacturing industry [14]. Similarly, Saudi Arabia formed the Saudi Space Commission and plans to launch its first domestic satellite by 2030. Egypt, with a long history in space, has launched multiple satellites for communication, remote sensing, and meteorology. Morocco has also sent several satellites, such as Mohammed VI-A and Mohammed VI-B, for mapping and monitoring natural resources and land use. Other Arab countries like Kuwait, Qatar, Bahrain, Oman, and Tunisia also have active space programs with a focus on satellite technology and applications.

However, the Arab world faces various challenges in the field of space technology research in addition to existing sustainability challenges reported by NASA [19]. These challenges include a lack of funding as many countries have limited budgets and may not have the resources to invest in large-scale space projects. Another limitation is the lack of the necessary infrastructure and resources to support space technology research and development. Additionally, space technology research and development often rely on international cooperation and partnerships, but many Arab countries may not have the same level of access to international partners and collaborations as other countries.

A comparison of the Arab world's space exploration with other regions reveals some key differences in terms of the scope, focus, and drivers of their space activities [20]. For example, the level of investment in space activities is still relatively low when compared to countries such as the United States, Russia, or China, which have invested heavily in their space programs for decades. Furthermore, the Arab world has only recently increased its investment in space technology, with the UAE and Saudi Arabia being the most active. Another difference is the focus on space activities, with many developed countries having a long history of human spaceflight and planetary exploration, while the Arab world has primarily focused on developing satellite technology for Earth observation, remote sensing, and satellite-based navigation. The drivers of space activities in the Arab world are also distinct from those of other regions, with developed

countries having a range of motivations for their space programs such as scientific discovery, while the Arab world's involvement in space is primarily driven by economic and strategic considerations such as improving communication and transportation infrastructure and providing valuable data for economic development.

Despite the significant contributions of the Arab world in space exploration, there is a scarcity of research on specific trends and developments in the field within the region. To the best knowledge of the author, no study has employed bibliometric analysis to examine the state of space technology research in the Arab world. This study aims to address this gap by conducting a bibliometric analysis of scientific literature pertaining to aerospace technology within the in the Arab countries based on the Scopus database.

III. DATA AND METHOD

The research methodology used in the present study is based on a quantitative and qualitative approach using bibliometric analysis and the Visualization of Similarities (VOS) method [16]. An important aspect of a bibliometric analysis on space exploration is the examination of the relationships between different publications conducted based on citations, co-authorship, or other mapping processes.

Conducting a bibliometric analysis includes several steps as outlined in Table 1. Firstly, a database containing relevant literature, such as journal articles, conference proceedings, or book chapters, must be selected. Popular databases for this include Web of Science, Scopus, dimension, Lens, and Google Scholar. Then, relevant keywords are identified by conducting a literature review to determine commonly used terms in the field. These keywords are then used to construct search queries in the chosen database. After the search is completed, the data is extracted and imported into a CSV file for analysis. This can include primary analysis of the data within the database, such as the chronological distribution of documents by year, source, affiliation, country, author, type, or subject area. The search results can also be refined using these criteria. Finally, we use the VOSviewer version 1.6.18 [21] software tool commonly used for creating and analyzing networks of bibliographic data.

TABLE I. STEPS FOR BIBLIOMETRIC ANALYSIS

Steps for Bibliometric Analysis	Description
Selecting a database	Carry out the process of selecting a database that contains publications such as journal articles, conference proceedings, or book chapters. This list can be obtained from databases like Scopus, Web of Science, Lens, or Google Scholar.
Identifying keywords	Identify the appropriate keywords by conducting a comprehensive literature review to investigate the keywords commonly used by authors in the field.
Constructing query strings	Construct and formulate query strings that match the nearest matching publications to be used in the search field of the database.
Extracting and analyzing data	Extract the data and import it as a CSV file, while conducting a primary analysis of the data within the database. The results of the search may include a chronological distribution of documents by year, source, affiliation, country, author, type, or subject area. This also enables the user to refine the results.
Visualizing and analyzing results	Utilize visualization tools such as VOSviewer to analyze the data, draw conclusions about the

	research landscape, and create diagrams such as network diagrams to visualize the relationships between authors, institutions, or journals, or diagrams to display the distribution of publication years or subject areas.
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The present bibliometric study uses search strings to identify articles related to space exploration in the Arab world applied to the title, abstract, and keywords using TITLE-ABS-KEY in the Scopus database. A retrieval search using keywords and Boolean for the closest matching of published articles was performed based on the English language from the year 1980-2022 as shown in Table 2.

TABLE II. QUERY FOR SPACE EXPLORATION IN THE ARAB WORLD

Description	Query
Space Exploration	"Aerospace" OR "Astronaut*" OR "Astrophysics" OR "Astronomy" OR "Astrophysics" OR "CubeSat" OR "Mars Mission" OR "Space Application*" OR "Space Exploration" OR "Space flight" OR "Space Industry" OR "Space Mission" OR "Space Orbit*" OR "Space Rocket" OR "Space Satellite" OR "Space Science" OR "Space Shuttle*" OR "Space Optic*" "Space station" OR "Space Station*" OR "Space technology" OR "Spacecraft" OR "Space Technology" OR "Space Agency"
Arab Countries	algeria OR bahrain OR comoros OR djibouti OR egypt OR emirates OR "United Arab Emirates" OR gcc OR iraq OR jordan OR kuwait OR lebanon OR libya OR mauritania OR mena OR morocco OR oman OR palestine OR qatar OR saudi OR "Saudi Arabia" OR somalia OR sudan OR syrian OR tunisia OR yemen
Publication Year	From 1980 to 2022
Language	English

IV. RESULTS AND DISCUSSION

An in-depth analysis of published articles in the Scopus database revealed that the number of publications on space exploration in the Arab world, although relatively low in comparison to other regions, has been on a steady increase over time. The highest number of publications was recorded between 2005 and 2021, as shown in figure 1. However, there was a significant drop to only 8 publications in 2022. Despite this, the number of citations for these publications continued to rise, particularly in 2022. This suggests that the quality and impact of the research being conducted in the Arab world on space exploration is increasing.

The top five Arab countries in terms of publications were the UAE, Egypt, Saudi Arabia, Algeria, and Morocco, as shown in figure 2. These countries have been actively investing in and promoting space exploration, which has led to an increase in the number of publications and citations.

As shown in figure 3, the most frequently covered subject areas in the published documents were earth and planetary sciences, engineering, computer science, environmental science, and mathematics and social sciences. This highlights the diverse range of research being conducted in the Arab world on space exploration, covering various scientific disciplines.

The top active centers in aerospace exploration were found to be the Mohamed bin Rashid Space Center and the UAE Space Agency. These institutions have been at the forefront of space exploration in the Arab world, leading research and development efforts in the field. The top funders were also

identified as the UAE Space Agency, King Abdulaziz University, and King Saud University. These organizations have been providing significant financial support for research and development in space exploration in the Arab world.

Overall, this analysis suggests that the Arab world has been making significant strides in the field of space exploration in recent years. The increase in publications and citations, as well as the diversity of subject areas and active institutions and funders, indicate a growing interest and investment in this field in the Arab world. It is expected that this trend will continue in the future, and the Arab world will become a significant player in space exploration.

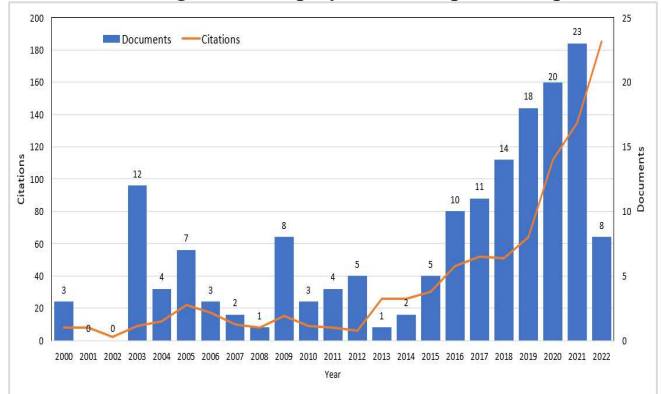


Fig. 1. Documents and citations distribution by year.

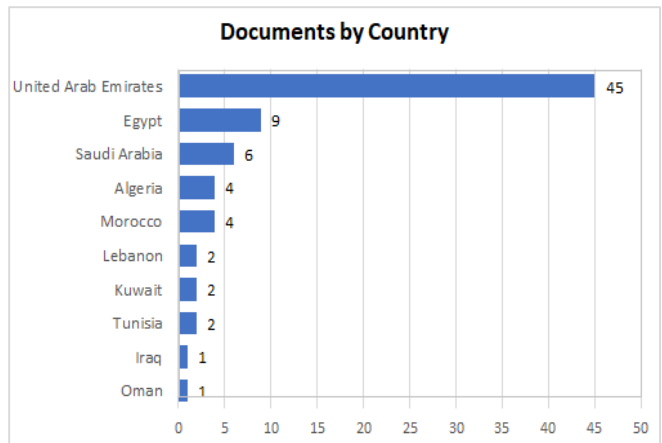


Fig. 2. Documents and citations by country.

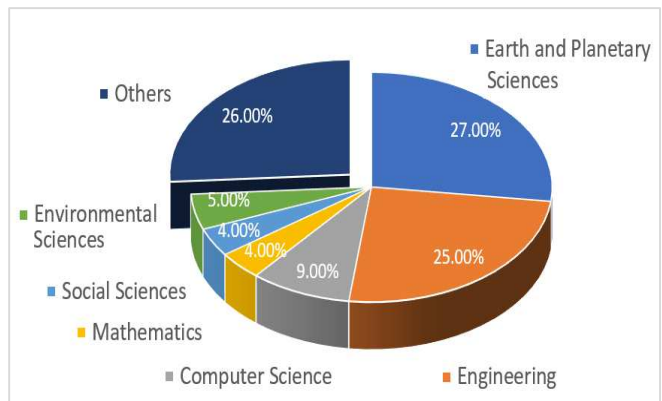


Fig. 3. Distribution of document by subject area.

As shown in Figure 4, the output generated by VOSviewer illustrates the co-occurrence patterns between keywords. This

visualization tool allows for the identification of relationships between keywords based on their frequency of co-occurrence in papers found within bibliographic databases. The size of each keyword node represents its frequency of occurrence, while the strength of the edges connecting the nodes indicates the level of association between the keywords. Through this analysis, we can gain insight into the most frequently discussed topics, as well as the relationships and connections between different concepts within the field of space exploration in the Arab world. This can aid in identifying key areas of research, potential collaborations, and areas for future study.

The resulting network, composed of nodes representing keywords and edges representing co-occurrence relationships, can be used to identify patterns and emerging trends in space exploration. The analysis indicates that the majority of publications in this field focus on remote sensing, the utilization of optical systems, satellites, space flight, and the aerospace industry. It should be noted that the size of the circles in the network represents the number of documents in which the keyword appears, with larger circles indicating a higher number of documents. The distance between two nodes represents the strength of the connection between them, with shorter distances indicating stronger connections. Additionally, the thickness of the lines between nodes denotes the frequency with which those keywords co-occur.

An examination of the overlay visualization presented in Figure 5 reveals that recent publications in the field of space exploration in the Arab world have been focusing on a number of key topics. These include Mars, space radars, space sciences, and the International Space Station. This is likely due to the increasing activities and investments in these areas by countries such as the United Arab Emirates. The overlay visualization allows for the identification of the most frequently discussed topics within the field, as well as the relative importance of each topic, which can aid in identifying key areas of research, potential collaborations, and areas for future study.

Density visualization is another feature in VOSviewer used for identifying patterns and trends in the data and areas of high and low concentration within the data. The density visualization of the keyword occurrence is illustrated in figure 6. Each color represents a different density of data, the red color (remote sensing and space optics) indicates a high density of data, while the blue color (space surveillance)

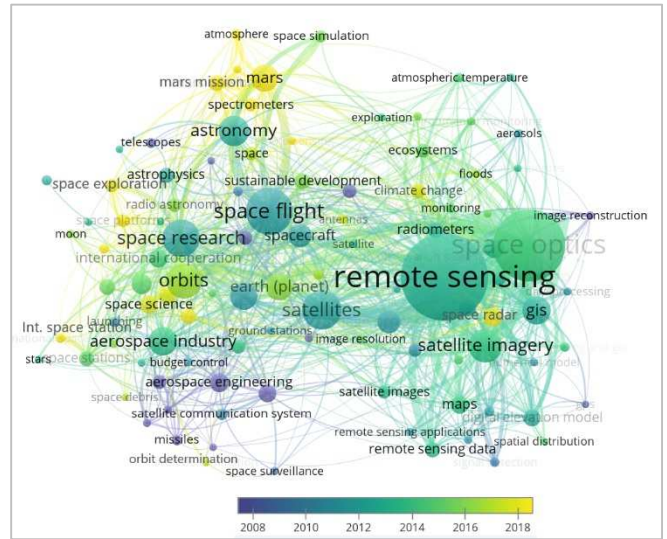


Fig. 5. Overlay Co-occurrence of keywords.

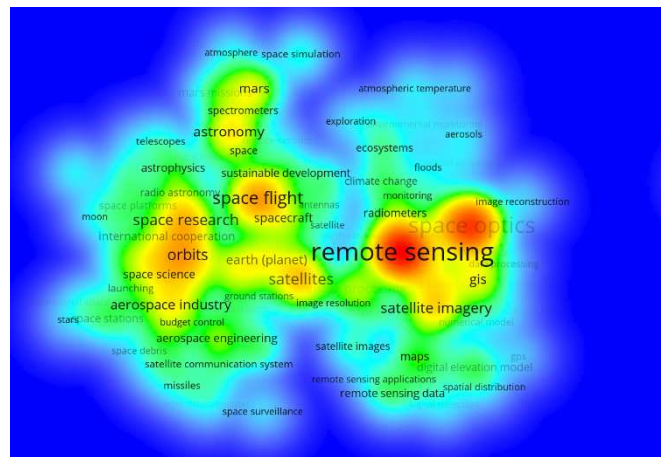


Fig. 6. Density visualization of keywords.

V. CONCLUSION

This study used bibliometric analysis to investigate the trends and advancements in aerospace research in the Arab world. Results revealed that from 1980 to 2022, a limited number of 154 documents were published in this field, primarily focusing on remote sensing and the use of optical systems in space exploration. The analysis also revealed that recent publications have primarily focused on Mars, space radars, space sciences, and the International Space Station, likely due to increasing activities in the United Arab Emirates. The top five most active countries in terms of publications were the UAE, Egypt, Saudi Arabia, Algeria, and Morocco, with the most popular subject areas being related to earth and planetary sciences. The study also highlighted the top active centers and funding sources in the Arab world's space sector. This study provides valuable insights into the state of technological innovation in the Arab world's space sector and suggests potential areas for future research.

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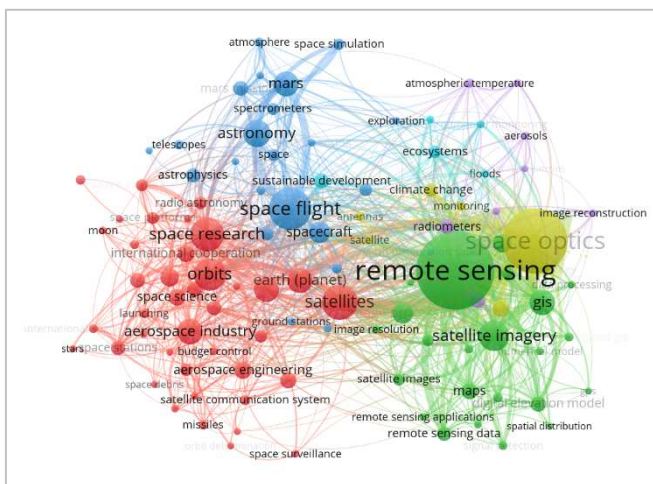


Fig. 4. Network visualization of keywords co-occurrence

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