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Research Article

Neoteric Trends of Unmanned Aerial Vehicle (UAV) Research: A Scientometric Analysis

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ABSTRACT

Artificial intelligence is becoming more prevalent across diverse disciplines, and aerial vehicles are increasingly becoming "Unmanned". It is beneficial when residents might otherwise be in danger, such as during COVID-19 medicine delivery, gathering information about the enemy, or using it in agriculture. This study aims to provide a scientometric assessment of the latest research centres, patterns, and global reach of UAVs from 2007 to 2022. The study uses bibliographic information downloaded in CSV format from Scopus to examine the in-depth visualization of the index item's properties. In addition to examining article expansion, field classifications, global dispersion, citation analysis, and the impact of the institutions and writers, the study examines UAV applications distributed throughout the world. To analyse term co-occurrence, we use a Java-based program called VOSviewer, which lists hubs and the latest innovations in UAV research.

Keywords: Blockchain, Drones, IoT, Scientometrics, UAV.

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INTRODUCTION

A UAV is a general-purpose plane designed to fly without a human pilot, per the perception and evaluation of an Unmanned Vehicle System (UVS). In public, the term "UAV" is still frequently used. Other terms are also frequently used, depending on the propulsion technique, air density, and extent of automation in aircraft operation. These terms include drone, remotely operated vehicle, remote controlled aviation, remotely piloted aerodyne devices, micro-aeronautical vehicles, autonomous fighter devices, remote-controlled hovercraft, and model hovercraft.[1] UAVs are described as "uninhabited air vehicles"[2] and as "uninhabited and reusable motorized aerial vehicles".[3] Scientometrics is a field that focuses mostly on evaluating and survey of scientific research.[4] It serves as an essential predicate for the assessment of academic outputs. It is also among the most trustworthy techniques to monitor developments in science and technology.[5] Through the knowledge map, scientometrics can examine scientific epicentres and emerging vogue in a certain field and visually represent the information environment of each discipline.[6]

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LITERATURE REVIEW

This section reviews the literature on UAV research.

UAV

Numerous types of research have been done in the field of UAVs. Some of them are reviewed yearly. For 2022, work on "Obstacle Avoidance and Profile Ground Flight Test and Analysis for Plant Protection UAV" has been performed. The barrier evasion and characterization test scheme for crop protection UAVs is devised in this work. The test results are reviewed using an analysis of software and hardware for the two UAVs, "EAVISION E-A2021" and "XAG". Finally, the extensive application status of various obstruction evasion and portrayed technologies of crop protection UAVs is defined. The industry's limitations in these innovations are compiled, offering a key standard for crop protection UAVs' future development.[7] Another work intends to collect quantitative and qualitative data for 3D modelling, which can encourage more thorough wisdom of the metropolitan habitat and encourage the metropolitan to rejuvenate processes. The project analyses the assistance of UAVs to the semantic plotting procedure of metropolitan stretch.[8] For 2021, an article suggests deploying numerous collaborative drones that hover near the end clients and offer cutting-edge functionality as smart objects to save, process, or forward data as part of a data management platform. A cloud provider keeping watch over the vicinity will employ a deep learning model based on long-term memory to forecast user behaviour and transmit a copy of the most frequently requested data to the drones. Due to limited storage capacity, the duplicated data is divided amongst the UAVs according to position and computational workload.[9] The research represented a full set of non-linear gearing and regulator design processes for a modest electric rooted-wing unmanned aerial aircraft. First, the small fixed-wing UAV's non-linear mathematical and aerodynamic models are deduced. Then, the aerodynamic coefficients of the UAV are calculated using the Computational Fluid Dynamics (CFD) approach in this study, and experimental data are used to build models of the propelling system's constituent parts. The control system developed and used can fulfil the fundamental aviation task criteria, such as attitude stability, route tracking, and shifting between various checkpoints, with solid performance and modest steady-state error.[10] In 2020, a project using various photos and movies was completed in Nerja (Spain). Many implicit parameters were measured on the industrial smokestack and water resource reservoir. The employment of UAV visual applications in historic monuments was the subject of a SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats). Finally, a comparison of UAVs and traditional photography techniques was conducted. Compared to traditional methods, UAVs offer greater opportunities for image acquisition. When analysing historical assets, both technologies can be used and complimented.[11] Enhancing user connection and energy distribution in each time frame seeks to reduce the long-term standard dissemination of energy utilized by the users. However, in the presence of a high number of users, solving a Markov Decision Process (MDP) problem using the traditional relative value iteration (RVI) can suffer from the ill effects of multiplicity. Therefore, a distributed RVI approach is proposed as an alternative to decoupling the underlying issue into numerous solved small-scale MDP problems by reducing the dimension of the MDP problem. According to simulation results, the suggested methods can produce long-term mean transmitted energy usage than the traditional RVI algorithm and a benchmark method with biased policies.[12] In 2019, according to Blade Element Theory (BET), a systematic approach for determining a small set of criteria that ensure precise force and drag forecast was put forth. The effective planning and subsequent verification involve straightforward, practical experiments using a well-known rotor system and a specially designed quadrotor. The findings analysis highlights the modelling constraint of BET while demonstrating the technique's reliability. With the help of empirical observations, an improvement based on Blade Element Momentum Theory is implemented and proven.[13] A study investigates the application of the theory of radar stats depiction as the benchmark for assessing the data capturing abilities of the connected UAV radar systems rather than the traditional measure of Signal-to-Interference Ratio (SIR). The research suggests a revised QLearning technique on a double greedy algorithm to improve the anti-obstruction efficiency of the connected UAV radar systems via collaborative engineering in the frequency-motion antenna domain. Simulation results demonstrate the algorithm's efficacy in two distinct networking environments.[14] In 2018, a study introduced a novel data-collecting technique designed to gather data from terrestrial Internet of Things devices within a predetermined time frame by enabling deployment and mobility among UAVs. In addition, the suggested technique collected data using IoTs and UAVs with the least energy possible.[15] The use of visual and thermal images captured by UAVs for monitoring photovoltaic installations is the subject of one piece of writing. Orthomosaics were created for inspection using visual and thermal pictures of solar panels taken by UAVs from various sites and under various acquisition settings and variables.[16] The researcher's dataset was acquired through a mission in Rabat, Morocco, and foreign datasets and used to evaluate the methods. As a result, several visual flaws, such as fractures, stains, and spots, were found in visual RGB and thermal orthomosaics. Additionally, a method of capturing hotspots that is semi-automatic was created and is provided in this paper.[17]

At Numerous research has been done in scientometrics, covering multiple fields. In an analysis, the immediacy index is used to compare individual research articles to the journal to determine the weight of research papers published in Nature. A comparative assessment of the top contributing nations based on the Nature Index has also been produced to check for bias in Nature articles.[5] In a paper, research on the developing field of "Big Data" is analysed using scientometrics. The publication presents a concise and scientometric analysis of "Big Data" work.[18] Full scientometric research of the Computer Science (CS) research findings from Mexico from 1989 to 2014 that was indexed in the Web of Science is presented in another paper. Only the top ten Mexican institutions create the whole body of Computer Science papers.[19]

Objectives

The main objective of this study is to use scientometric analysis to examine various UAV research application sectors from 2007 to 2022. The goals of this study are to;

i. Evaluate publication growth patterns and subject categories.

ii. Recognize country collaborations and allocation of the UAV research globally.

iii. Assess document citation trends.

iv. Classify impactful journals.

v. Expose research hotspots, trends, and gaps in numerous UAV research application domains.

The research community will benefit from this paper's explanation of the fundamentals, boundaries, and most recent developments in the UAV field.

The following are the study's main contributions;

i. In addition to revealing the recent developments and scientific explorations in the UAV field, it also visualized and analysed the various bibliometric characteristics of study in the UAV domain.

ii. Recognised international research collaboration.

iii. Found the current set of circumstances and upcoming research road map.

iv. Revealed the research collaboration between various countries.

The paper is set up to present various scientometrics attributes in UAV. The technique, source of data, and visualization tool are covered in Section 2. Sections 3 and 4 separately cover publication evolution and citation monitoring. Section 5 analyses and visualizes the worldwide UAV research collaboration. Section 6 finds hotspots and the most recent UAV fields and keyword co-occurrence analysis is discussed. Section 7 discusses the distributed processing applications of UAVs. The study is discussed in Section 8, including the future scope of work, followed by the Conclusion Section 9.

METHODOLOGY

ISIC Citation Indexes was among the few sources that were available prior to 2004 to access citation databases of scientific literature. After that, several substitutes for ISI citations emerged, including Scopus,[20] Google Scholar, and Web of Science (WOS). When Scopus first debuted in November 2004 it was known as SciVerse Scopus.[21] The source titles are arranged in Scopus according to the fields, and All Science Journal Classification (ASJC) is used to map the sub-field.[21,22] The Scopus database is used to find UAV's bibliographic information. First, the Document tab is chosen on the webpage. Next, a drop-down menu with the caption "Search Within" is located just after the document tab. Next, choice 2 labelling the Article title, is marked. The next item is a text box marked Search Documents. Finally, the search phrase UAV is entered here. Now that the range of years has been selected from 2007 to 2022 (both years inclusive), filters have been applied to search results: Document Type, Subject Area, Source Type, and Publication Stage. The final search term is "(TITLE-ABS-KEY (UAV) AND PUBYEAR > 2006 AND PUBYEAR < 2023 AND (LIMIT-TO (PUBSTAGE, "final")) AND (LIMIT-TO (DOCTYPE,"ar")) AND (LIMIT-TO (SRCTYPE, "j")) AND (LIMIT-TO (EXACTKEYWORD, "Drones") OR LIMIT-TO(EXACTKEYWORD, "Unmanned

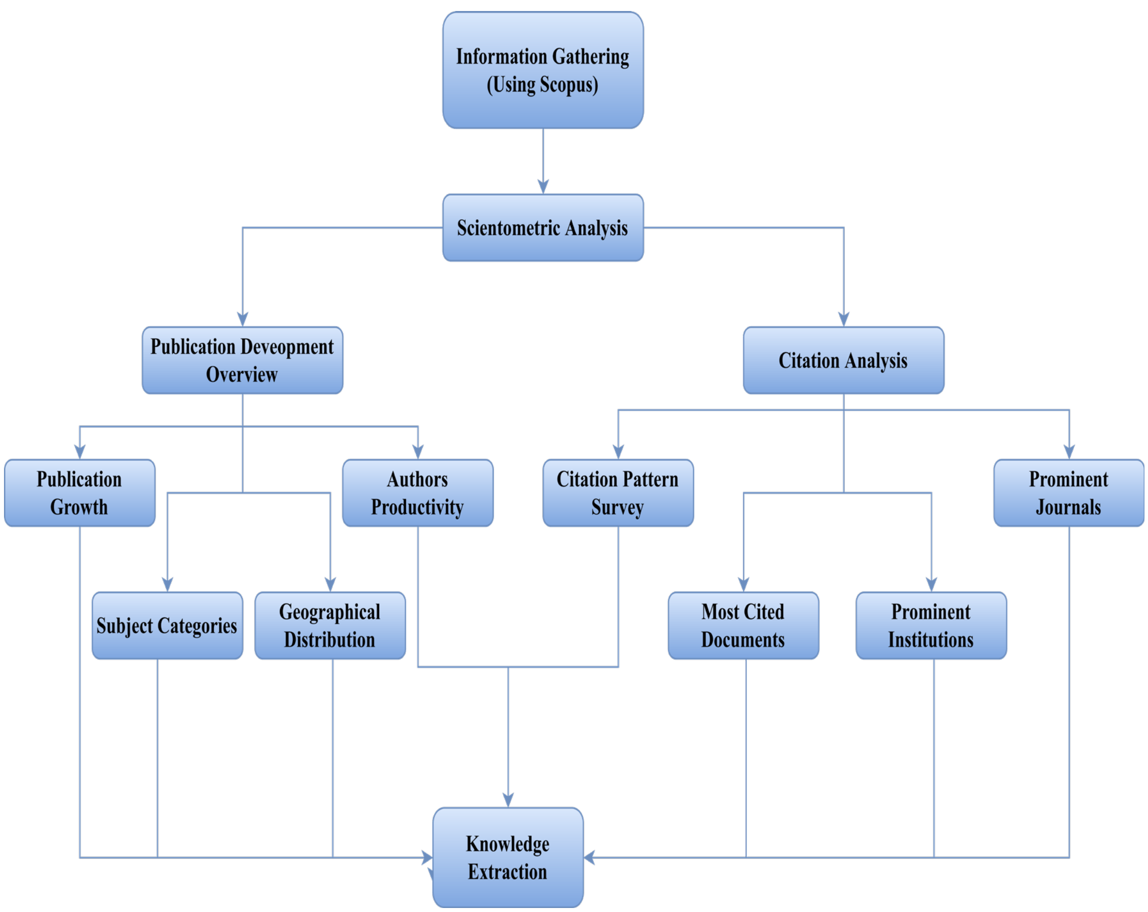

Figure 1: Flow chart of Process followed.

Table 1: Yearly Extension rate of UAV research from 2007 to 2022.

Year	Number of Publications	AGR (%)
2007	6	-
2008	14	1.333
2009	26	0.857
2010	19	-0.269
2011	23	0.211
2012	34	0.478
2013	48	0.412
2014	82	0.708
2015	106	0.293
2016	164	0.547
2017	283	0.726
2018	429	0.516
2019	634	0.478
2020	793	0.251
2021	1046	0.319
2022	721	-0.311

Table 2: Top Ten authors in UAV research from 2007 to 2022.

Author Name	Publications Frequency
Ollero, A.	24
Savkin, A.V.	22
Sharma, V.	21
Guizani, M.	18
Huang, H.	17
Yanikomeroglu, H.	16
Han, Z.	15
Saad, W.	15
Alouini, M.S.	14
Guvenc, I.	13

Aerial Vehicles") OR LIMIT-TO (EXACTKEYWORD, "Drone") OR LIMIT-TO (EXACTKEYWORD, "Internet Of Things") OR LIMIT-TO (EXACTKEYWORD, "Unmanned Aerial Systems") OR LIMIT-TO(EXACTKEYWORD,"UAVs") OR LIMIT-TO (EXACTKEYWORD,"5G Mobile Communication Systems")) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMITTO (SUBJAREA,"ENGI") OR LIMIT-TO (SUBJAREA,"COMP") OR LIMIT-TO (SUBJAREA,"EART") OR LIMIT-TO (SUBJAREA,"MATH") OR LIMIT-TO (SUBJAREA,"PHYS") OR LIMIT-TO (SUBJAREA,"MATE") OR LIMIT-TO (SUBJAREA,"ENVI") OR LIMIT-TO (SUBJAREA,"BIOC") OR LIMIT-TO (SUBJAREA,"AGRI") OR LIMIT-TO (SUBJAREA,"CHEM") OR LIMIT-TO (SUBJAREA,"ENER") OR LIMITTO (SUBJAREA,"DECI")))", there are several other restrictions to keywords.Four thousand four hundred twenty-eight documents are returned in response to this search. The outcomes were saved as a CSV file. Writers, subject, year, issue, organizations, editor, and many other things about the bibliography are included. These bibliographic records are examined to look for undiscovered information. A visualization tool is necessary for creating networks using bibliographic data. Gephi,[23] CiteSpace,[24] UClnet,[25] VOSviewe,[26] and other tools are a few of the most popular ones. Figure 1 displays the process followed in the study. The primary advantage of VOSviewer is that it can create massive networks of bibliographic data and is freely accessible via the internet.[27] Java is the programming language used to create it. It offers several map creations options, including using database files (Scopus, Web of Science, etc.), reference management files (RIS, EndNote, etc.), and API (Application Programming Interface) downloads from sites like Microsoft Academic API, Crossref API, etc. It provides network, overlay, and density map visualizations. It also offers panning, rolling, and other features for usage with expansive maps that contain a variety of objects. Therefore, this study evaluates and visualizes UAV research using the VOSviewer tool.

Publication Development Overview

Publication Growth

The rise of UAV articles from 2007 to 2022 is seen in Figure 2. Among 4428 publications, six papers were published in 2007, 14 in 2008, 26 in 2009, 19 in 2010, 23 in 2011, 34 in 2012, 48 in 2013, and 82 in 2014. Starting from 2015, the number of publications was in the hundreds i.e., 106 in 2015, 164 in 2016, and 283 in 2017. The number of publications pursued a rise in 2018 and kept growing. There were 429 publications in 2018, 634 in 2019, 793 in 2020, 1046 in 2021, and 721 up until the middle of 2022. This discipline is prominent for research because more articles have been published over time. The number of publications increased significantly in 2021 compared to the previous year, 2020. UAV research's Annual Growth Rate (A.G.R.) is displayed in Table 1 from 2007 to mid-2022. The formulae provide the calculating formula for the A.G.R. Table shows the annual growth rate of UAV research from 2007 to mid-2022. The calculating formula for the A.G.R. is provided in the formulae (1):

$$A_{gr} = \frac{C_{yt} - P_{yt}}{P_{yt}} \times 100 \quad (1)$$

where Agr is A.G.R., Cyt is current year term and Pyt is previous year term. A.G.R. calculations reveal that articles have consistently grown over time, with a notional surge between 2020 and 2021. The fact that 2022 has a negative A.G.R. is because the year has not yet ended and is still considered for analysis.

Subject Categories

The UAV research covers several subject areas. The broad subject categories for which UAV research is conducted are displayed in Figure 3. The article occurrences acquired from the Scopus database are used for the analysis. The analysis yields a percentage share of UAV research across many fields. Engineering and computer science comprise the majority of contributors, with 2677 and 2357 occurrences, respectively. With 703, 566, 500, and 420 occurrences each, Earth and Planetary Sciences, Mathematics, Physics and Astronomy, and Materials Science are other categories with noteworthy occurrences. The analysis demonstrates that this research topic is multidisciplinary and has numerous applications. It is not restricted to a single domain.

Geographical Distribution

Information gathered from the Scopus database analyses the Geographical Distribution of the research field. It demonstrates that the United States has made the largest proportion of contributions of 15.07 % to UAV research. China comes in second with 13.71% of the articles, followed by the United Kingdom on its own with 5.14%. Canada contributes 4.37% to UAV research, second only to the United Kingdom. Four percent comes from Italy and South Korea. India, Australia, and Spain each provide about 3% of all UAV research.

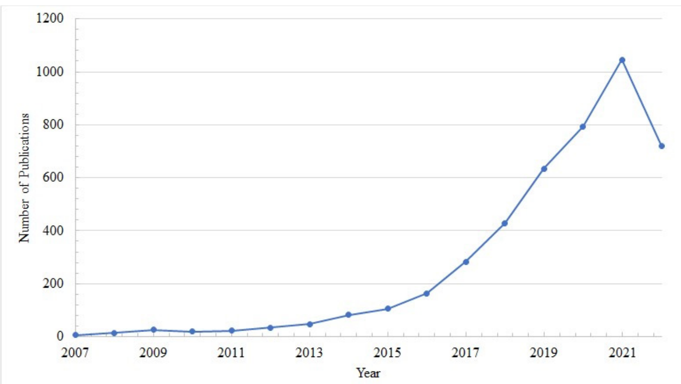

Figure 2: UAV research publications trends from 2007 to 2022.

Authors Productivity

Table 2 lists the top ten high-yielding authors according to the article frequency statistics gathered from the Scopus database for 2007 to 2022. With a frequency of 24 articles, Ollero, A. is the most productive author, followed by Savkin, A.V., and Sharma, V., who both have a frequency of 22 and 21, respectively. Guizani, M. contributed 18 papers, followed by 17 and 16 papers from Huang, H., and Yanikomeroglu, H., respectively. There were 15 articles each from Han, Z., and Saad, W. Of Alouini, M.S. and Guvenc, I. have written 14 and 13 articles, respectively.

Analysis of Citations

Citation Pattern Survey

The citation style is covered in this section. Analysis of the citation frequency revealed that it is insufficient to assess the importance of a publication on its own. The Normalized Citation Impact Index (NCII) is used to evaluate the importance of articles based on their consistency over time.[28] The percentage of total citations per publication and the lifespan of the publication are what make up the NCII.

$$N_I = \frac{Avg_{cp}}{P_l} \quad (2)$$

where N_I is NCII, Avg_{cp} is average citation to publication proportion and P_l is Lifetime of Publication Analysing the 92614

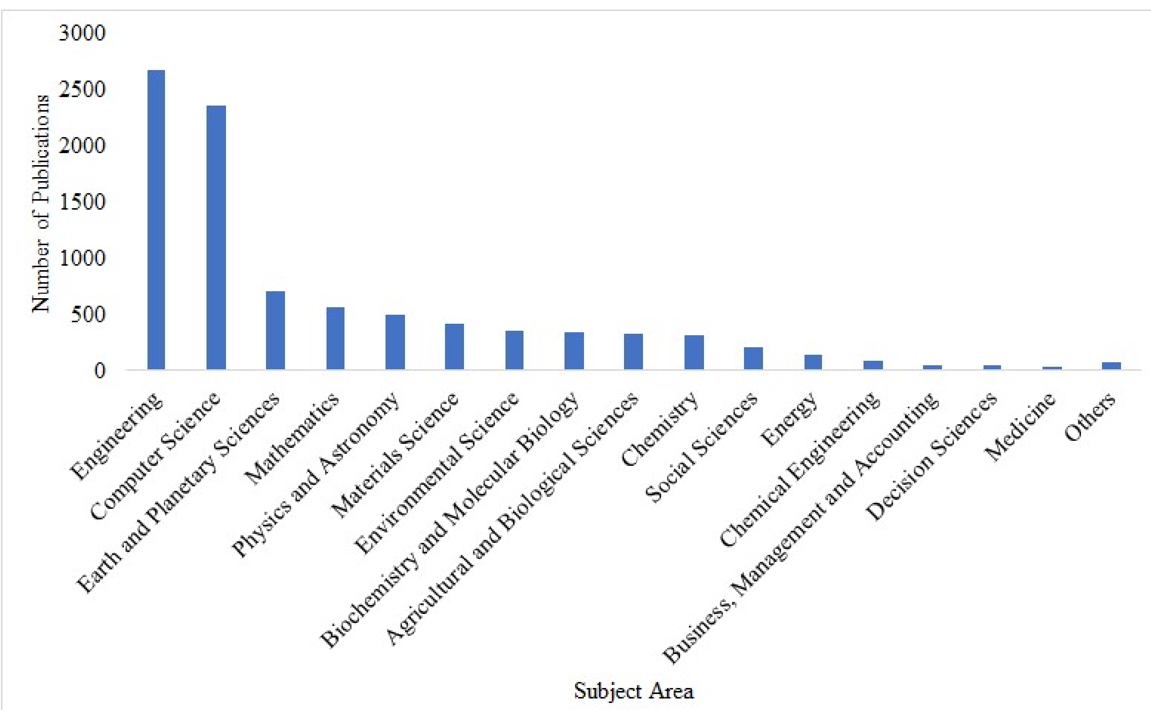

Figure 3: Subject categories of UAV Research.

Table 3: Most cited papers in UAV research from 2007 to 2022.

Rank	Document Title	Authors	Journal Title	Year	Citations	I_n	NCII
1	"A Tutorial on UAVs for Wireless Networks: Applications, Challenges, and Open Problems".[32]	Mozaffari M., Saad W., Bennis M., Nam Y.-H., Debbah M.	IEEE Communications Surveys and Tutorials	2019	944	2	472
2	"Unmanned aircraft systems in remote sensing and scientific research: Classification and considerations of use".[33]	Watts A.C., Ambrosia V.G., Hinkley E.A.	Remote Sensing	2012	606	9	67.33
3	"Mobile Unmanned Aerial Vehicles (UAVs) for Energy-Efficient Internet of Things Communications".[31]	Mozaffari M., Saad W., Bennis M., Debbah M.	IEEE Transactions on Wireless Communications	2017	586	4	146.5
4	"Distributed optimization over time-varying directed graphs".[31]	Nedic A., Olshevsky A.	IEEE Transactions on Automatic Control	2015	579	6	96.5
5	"The flying sidekick traveling salesman problem: Optimization of drone-assisted parcel delivery".[34]	Murray C.C., Chu A.G.	Transportation Research Part C: Emerging Technologies	2015	573	6	95.5
6	"Placement Optimization of UAV-Mounted Mobile Base Stations".[35]	Lyu J., Zeng Y., Zhang R., Lim T.J.	IEEE Communications Letters	2017	556	4	139
7	"3-D Placement of an Unmanned Aerial Vehicle Base Station (UAV-BS) for Energy-Efficient Maximal Coverage".[36]	Alzenad M., El-Keyi A., Lagum F., Yanikomeroglu H.	IEEE Wireless Communications Letters	2017	538	4	134.5
8	"UAV communications for 5G and beyond: Recent advances and future trends".[37]	Li B., Fei Z., Zhang Y.	IEEE Internet of Things Journal	2019	531	2	265.5
9	"Caching in the Sky: Proactive Deployment of Cache-Enabled Unmanned Aerial Vehicles for Optimized Quality-of-Experience".[38]	Chen M., Mozaffari M., Saad W., Yin C., Debbah M., Hong C.S.	IEEE Journal on Selected Areas in Communications	2017	524	4	131
10	"A Comprehensive Review of the COVID-19 Pandemic and the Role of IoT, Drones, AI, Blockchain, and 5G in Managing its Impact".[39]	Chamola V., Hassija V., Gupta V., Guizani M.	IEEE Access	2020	497	1	497
11	"Vehicle Routing Problems for Drone Delivery".[40]	Dorling K., Heinrichs J., Messier G.G., Magierowski S.	IEEE Transactions on Systems, Man, and Cybernetics: Systems	2017	487	4	121.75

Rank	Document Title	Authors	Journal Title	Year	Citations	l_n	NCII
12	"Overview and current status of remote sensing applications based on unmanned aerial vehicles (UAVs)". [41]	Pajares G.	Photogrammetric Engineering and Remote Sensing	2015	473	6	78.83
13	"Development of a UAV-LiDAR system with application to forest inventory ". [42]	Wallace L., Lucieer A., Watson C., Turner D.	Remote Sensing	2012	461	9	51.22
14	"UAV-Based IoT Platform: A Crowd Surveillance Use Case". [43]	Motlagh N.H., Bagaa M., Taleb T.	IEEE Communications Magazine	2017	438	4	109.5
15	"Accessing from the Sky: A Tutorial on UAV Communications for 5G and beyond". [44]	Zeng Y., Wu Q., Zhang R.	Proceedings of the IEEE	2019	425	2	212.5
16	"Evaluating multispectral images and vegetation indices for precision farming applications from UAV images". [45]	Candiago S., Remondino F., De Giglio M., Dubbini M., Gattelli M.	Remote Sensing	2015	393	6	65.5
17	"Survey on UAV Cellular Communications: Practical Aspects, Standardization Advancements, Regulation, and Security Challenges". [46]	Fotouhi A., Qiang H., Ding M., Hassan M., Giordano L.G., Garcia-Rodriguez A., Yuan J.	IEEE Communications Surveys and Tutorials	2019	388	2	194
18	"High spatial resolution three-dimensional mapping of vegetation spectral dynamics using computer vision". [47]	Dandois J.P., Ellis E.C.	Remote Sensing of Environment	2013	373	8	46.63
19	"A survey on technologies for automatic forest fire monitoring, detection, and fighting using unmanned aerial vehicles and remote sensing techniques". [48]	Yuan C., Zhang Y., Liu Z.	Canadian Journal of Forest Research	2015	367	6	61.17
20	"A UAV for bridge inspection: Visual servoing control law with orientation limits". [49]	Metni N., Hamel T.	Automation in Construction	2007	334	1	23.86

overall citations for UAV research reveals an average citation rate of 21 for each article. The year 2021 has the maximum count of citations and NCII, which indicates a significant increase for this year. A total of 4428 articles were included in the exploration, of which 116 had a least citation number of 116. So, 116 is the *h*-index. The thrust, importance, and influence of research are evaluated using the *h*-index indicator.[29]

Most Cited Documents

The proportion of citation occurrences to publication is displayed in the particulars acquired from the Scopus database. This section identifies the articles that had the greatest impact on research publications from 2007 to 2022 based on citations. In the UAV research with more than 300 citations, Table 3 lists the article's rank place, Document Subject, Author Title, Journal Title, Publication Year, Citations, Longevity (lg), and NCII value. It demonstrates that the article with the most citations is "A Tutorial

Table 4: Research journals with high citations on UAVs.

Source Title	C	D	N(c/d)	% Share	IF
"Remote sensing"	6950	164	42.38	3.704	4.509
"IEEE access"	4763	129	36.922	2.913	3.367
"IEEE internet of things journal"	4343	81	53.617	1.829	10.98
"Sensors (Switzerland)"	3728	123	30.309	2.778	3.576
"Journal of intelligent and robotic systems: theory and applications"	2791	75	37.213	1.694	3.61
"IEEE communications magazine"	2333	19	122.789	0.429	11.05
"IEEE communications surveys and tutorials"	2128	11	193.455	0.248	25.25
"IEEE transactions on vehicular technology"	2063	41	50.317	0.926	5.978
"IEEE wireless communications letters"	1879	23	81.696	0.519	4.348
"IEEE Journal on selected areas in communications"	1849	26	71.115	0.587	7.172
"IEEE transactions on wireless communications"	1834	26	70.538	0.587	7.016
"Remote sensing of environment"	1724	25	68.96	0.565	13.85
"IEEE Communications letters"	1629	16	101.812	0.361	3.436
"Transportation Research part c: emerging Technologies"	1450	13	111.538	0.293	8.089
"ISPRS Journal of Photogrammetry and remote sensing"	1187	18	65.944	0.407	11.77

Table 5: A ranking of the top UAV-research institutions from 2007 to 2022.

Institute Name	P	C	R(c/p)
"Mathematical and Algorithmic Sciences Laboratory, Huawei, France"	3	1735	578.33
"Centre for Wireless Communications, University of Oulu, Finland"	3	1372	457.33
"Department of Systems and computer engineering, Carleton University, Ottawa, Canada"	6	962	160.33
"Department of Electronic Engineering, Tsinghua University, Beijing, China"	10	958	95.8
"Centralesupelec, University Paris-Saclay, Gif-sur-Yvette, France"	1	944	944
"Standards and 5g mobility innovations laboratory, Samsung research America, Richardson, United States"	1	944	944
"Electrical and Computer Engineering, Virginia Tech, Blacksburg, United States"	1	944	944
"Sirte university, Sirte, Libya"	2	820	410
"Department of Computer Engineering, Kyung Bee University, Seoul, South Korea"	2	791	395.5
"National Mobile Communications Research Laboratory, Southeast University, Nanjing, China"	7	776	110.85

on UAVs for Wireless Networks: Applications, Challenges, and Open Problems", published in the journal "IEEE Communications Surveys and Tutorials". This study thoroughly explains the possible advantages and uses of UAVs in wireless communication systems. Furthermore, a comprehensive investigation is conducted into the significant difficulties and essential trade-offs in UAV-assisted wireless networks, "Unmanned aircraft systems in remote sensing and scientific research: Classification and considerations of use", which appeared in the journal "Remote Sensing" in 2012, is the second-most referenced paper. This paper discusses several architectures and sensing capabilities, highlighting the benefits of each concerning customer requirements in the scientific research field. To notify the research establishment about this technological innovation, which can fundamentally alter natural scientific findings, comparable to the changes that GIS and GPS helped bring approximately two decades ago, they also briefly discuss the condition of restrictions currently plaguing UAS processes.[30] The third most cited document is titled "Mobile Unmanned Aerial Vehicles (UAVs) for Energy-Efficient Internet of Things Communications" published in the journal "IEEE Transactions on Wireless Communications" in 2017. This study examines the effective deployment and maneuverability of several Unmanned Aerial Vehicles (UAVs) that serve as airborne ground stations for ground Internet of Things (IoT) devices to gather information. Specifically, a unique framework is presented for optimising the 3D location and the flexibility of the UAVs, device-UAV association, and uplink power regulation to enable effective uplink connections for the IoT devices with a reasonably low transmission power.[31] With 944 citations and NCII 472, "A Tutorial on UAVs for Wireless Networks: Applications,

Table 6: Clustering UAV research by keyword coexistence.

Cluster	Sphere Color	Keywords Prevalence	Terms
Cluster 1	Red	31	Unmanned Aerial Vehicles (UAV), drones, internet of things, 5g mobile communication systems, energy utilization, energy efficiency, mobile telecommunication systems, vehicle to vehicle communications, wireless networks, network security, wireless communications, edge computing, stochastic systems, wireless sensor networks, base stations, military vehicles, network architecture, wireless telecommunication systems, blockchain, signal to noise ratio, simulation, vehicular ad hoc networks, vehicle transmissions, security systems, ad hoc networks, intelligent systems, secondary batteries, approximation algorithms, commercial vehicles, disaster prevention, trucks.
Cluster 2	Green	22	Remote sensing, photogrammetry, cameras, mapping, aerial survey, global positioning system, satellite imagery, image analysis, image processing, environmental monitoring, accuracy assessment, crops, optical radar, lidar, automation, infrared devices, fighter aircraft, detection method, spectroscopy, ground control points, 3-D computer graphics, radar.
Cluster 3	Blue	21	Aircraft control, trajectories, controllers, air navigation, fixed wings, path planning, navigation, collision avoidance, robotics, flight simulators, agricultural robots, genetic algorithms, sensors, flight control systems, aerodynamics, remotely operated vehicles, target tracking, flight dynamics, flight paths, Particle Swarm Optimization (PSO), smart city.
Cluster 4	Yellow	13	Aircraft detection, data acquisition, deep learning, machine learning, learning systems, neural networks, computer vision, decision making, reinforcement learning, object detection, data handling, artificial intelligence, digital storage.

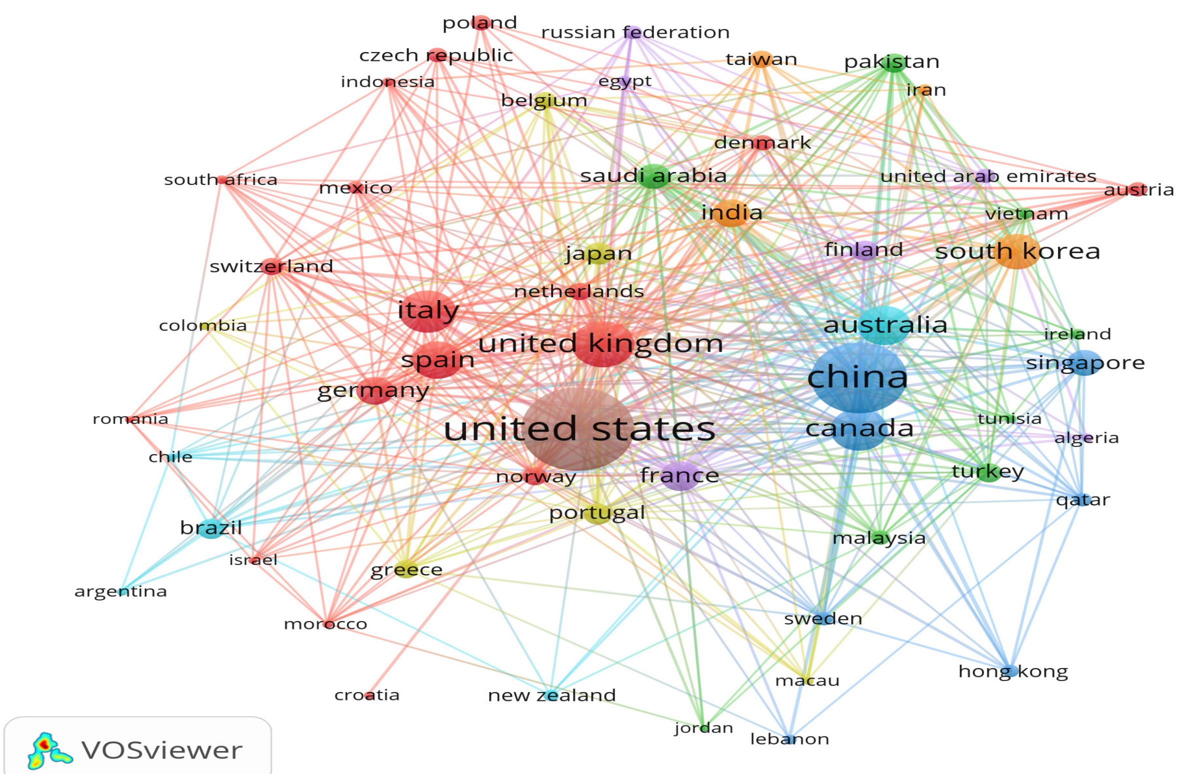

Figure 4: Participation of countries in UAV Research.

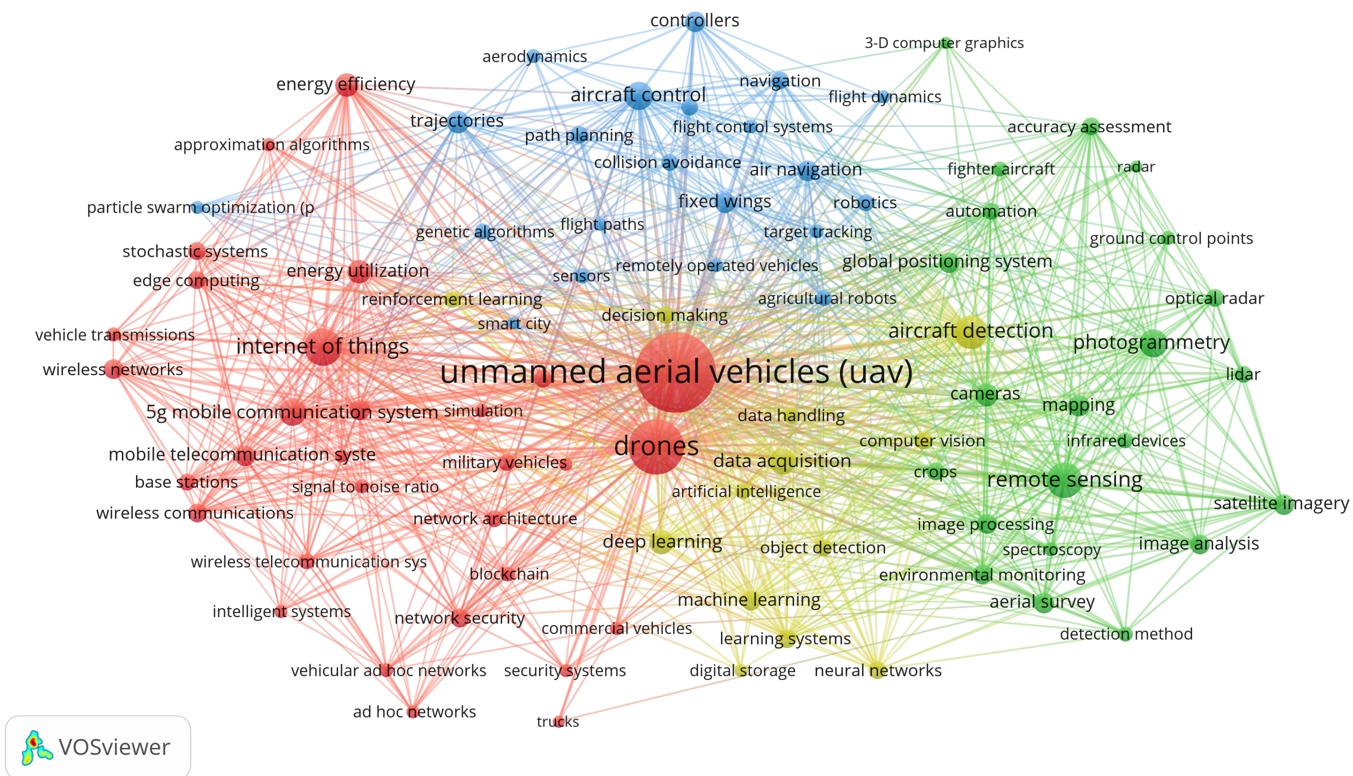

Figure 5: Network of keywords co-occurrence for UAV research.

Challenges, and Open Problems" is the most referenced article, followed by "Unmanned aircraft systems in remote sensing and scientific research: Classification and considerations of use" with 606 citations and NCII 67.33. "Mobile Unmanned Aerial Vehicles (UAVs) for Energy-Efficient Internet of Things Communications", with a citation sum of 586 and NCII 146.5, is the third-most referenced document. It is followed by "Distributed optimization over time-varying directed graphs", with a citation sum of 579 and NCII 96.5. Table displays the total number of citations and NCII for all documents with more than 300 citations.

Prominent Journals

This excerpt highlights the leading journals in the UAV area by assessing the journals' citation counts. Journals are one of the most precious assets influencing the academic community for forthcoming introspections. Therefore, it is crucial to calculate the sources impact on a certain research field. The references represent the journal's influence on a particular scientific field. The regularity with which a journal's research papers are cited serves as another indicator of the journal's importance. One of the widely used metrics communicated yearly in the "Journal Citation Reports" is the Impact Factor. The mean of all the total citations of the journal articles in the previous two years is used to determine a journal's impact factor for a given year.[29] Table 4 displays information on the major journals with more than 1000 citations. From 2007 to 2022, it highlights the journals with the maximum frequency of citations in the UAV research sector. Journal Title, which contains the name of the journal, Citations Occurrences (cf), Article Occurrences (nf), Proportion of Citations to Articles (cf/nf), Percentage of Publication (percent n), and Source Impact Factor (IF) are the fields in Table 4.

The journal "remote sensing" has the most citations (6950), the most articles (164), the most citations per publication (42.37), and the greatest publication share (3.703). Therefore, this journal's impact factor is 4.509. With 4763 citations, a publications occurrence of 129, and a citation to publications proportion of 36.922, the journal "IEEE access" comes in second place. This journal has an impact factor of 3.367 and a percent share of 2.913. "IEEE internet of things journal", a journal with 81 articles, 53.617 citations per article, a percentage share of 1.829, and an Impact Factor of 10.98, is the journal with the third-highest number of citations. "sensors (Switzerland)" (3.576,123), "Journal of intelligent and robotic systems: theory and applications" (3.61,75), "IEEE communications magazine" (11.05,19), and "IEEE communications surveys and tutorials" (25.25,11) are some more journals with significant impact factors and publication counts. It should be noted that "remote sensing" has the most articles—164—while "IEEE access" come in second with 129. Therefore, it is evident that the frequency of articles in that journal has no impact on the impact factor, as a journal with just one article may have the highest impact factor. Furthermore, most journals listed are from science and engineering, demonstrating the prevalence of UAVs in various scientific fields.

Prominent Institutions

This excerpt discusses the prominent journals in the domain of UAV research. Table 5 lists institutions in the field of UAV research based on the citations. All the institutions having a citation count greater than 700 are listed. p indicates the frequency of the documents published by the institutions, c is the citations, and r denotes the ratio of citations to publications.

As per the Table 5 "Mathematical and Algorithmic Sciences Laboratory" (1735) of Huawei, France has the highest aggregate of citations accompanied by the "Centre for Wireless Communications, University of Oulu" (1372) of Finland, "Department of Systems and computer engineering, Carleton University" (962) of Ottawa, Canada and "Department of Electronic Engineering, Tsinghua University" (958) of Beijing, China. It has been noted that two institutions are from "France", two from "China", two from "United States", and one each from "Finland", "Libya", and "South Korea". According to the data, the most prominent institutions in UAV research are from the United States and China.

Country Participation

This section uses the visualization tool VOSviewer to examine country collaboration for UAVs from 2007 to 2022. It demonstrates how the nation and the UAV research regions are related. Co-authorship is the method of analysis used, while the Countries with Full Counting method are the analysis unit. The minimum number of citations per nation has been set at five. In UAV research, 81 different nations have reported their findings. The country collaboration mesh of UAV research is represented in Figure 4 by a total of 55 nodes and 482 links. The node size indicates how many publications it contains; links indicate the relationships between countries, and colour indicates a cluster-the identical cluster has the identical node colors. Links and the Total Link Strength (TLS) are employed to determine the co-writing between two countries. The link displays the co-writing count relations of a writer with other writers. Total link strength reflects an author's gross co-authorship link strength with other authors.[50] According to Figure , "the United States" has the most documents (531), with a total link strength of 360, followed by "China" with 396 documents and a total link strength of 348. The total link strengths for "United Kingdom" (182), "Canada" (154), "Italy" (154), and "Australia" (138) are 228, 140, 104, and 134 points, respectively. Additionally, "the United States" (49), "the United Kingdom" (16), "Australia" (40), and "China" (34) have the highest relationship frequencies, respectively, when compared to the frequency of links.

The Research Centres and Trends of UAV Research

The section examines research centres and current trends in the field of UAVs for fifteen years, from 2007 to 2022. Maps of keyword co-occurrence networks were created using both indexed and author keywords. The groupings were examined to determine the research's hot spots. The categorization is done based on identical fields. Using keyword co-occurrences allows for examining keyword associations and detecting studies in publications over time. The keyword co-occurrence mesh is built and studied for UAV research epicentres. VOSviewer is utilised to display the keyword co-occurrence connection among several terms. The cooccurrence network clusters are depicted in Table 6.

The very first batch (Red color, Cluster 1) has 31 keywords that are related. This cluster's work is on "drones", the "internet of things". The cluster's primary study interests are vehicles, networking, vehicle-to-vehicle communication, and computing. The next batch (Green color, cluster 2) has a co-occurrence network of twenty-two keywords. The study's major focus is on remote sensing. cameras, aerial surveys, global positioning systems, and image analysis. The third batch (Blue, Cluster 3) includes a term co-occurrence network of twenty-one keywords focused on Aircraft Control. The cluster's main research topics include trajectories, controllers, robotics, and flight control systems. The final batch (Yellow, Cluster 4) includes a term co-occurrence network of thirteen keywords focused on aircraft detection. The cluster's main research topics include data acquisition, deep learning, machine learning, and computer vision.

The keyword occurrence distribution (percent) for Cluster 1 is shown in 5A "unmanned aerial vehicles (UAVs)" is estimated to have a share of (41.6%) in the cluster, whereas "Drones" have (17.2%) portion of the cluster. Other notable technologies in this cluster are the Internet of Things (7.2%), 5G Mobile Communication (3.4%), and Energy Utilization with a share of (2.4%).

Cluster 2 breakdowns of different keyword occurrences are displayed in 5B. The phrase with the most shares is "Remote Sensing", with an estimated % share of 17.6%, photogrammetry (9.9%), Cameras (6.0%), and Mapping (5.3%). Other participants are adding their share to this cluster, including aerial surveys (5.0%), global positioning systems, and satellite imagery, with a common split of 4.98 percent.

The percent share of keyword occurrences in Cluster 3 is displayed in 5C. Aircraft control contains the highest split in the cluster, with 14.4 percent. Others, including trajectories (8.5%), controllers (7.3%), and air navigation (7.2%), also have a remarkable contribution to the cluster.

The percent share of keyword occurrences in the final Cluster 4 is displayed in 5D. Aircraft detection contains the highest split in the cluster with 23.8 percent. Others, Data acquisition (12.9%),

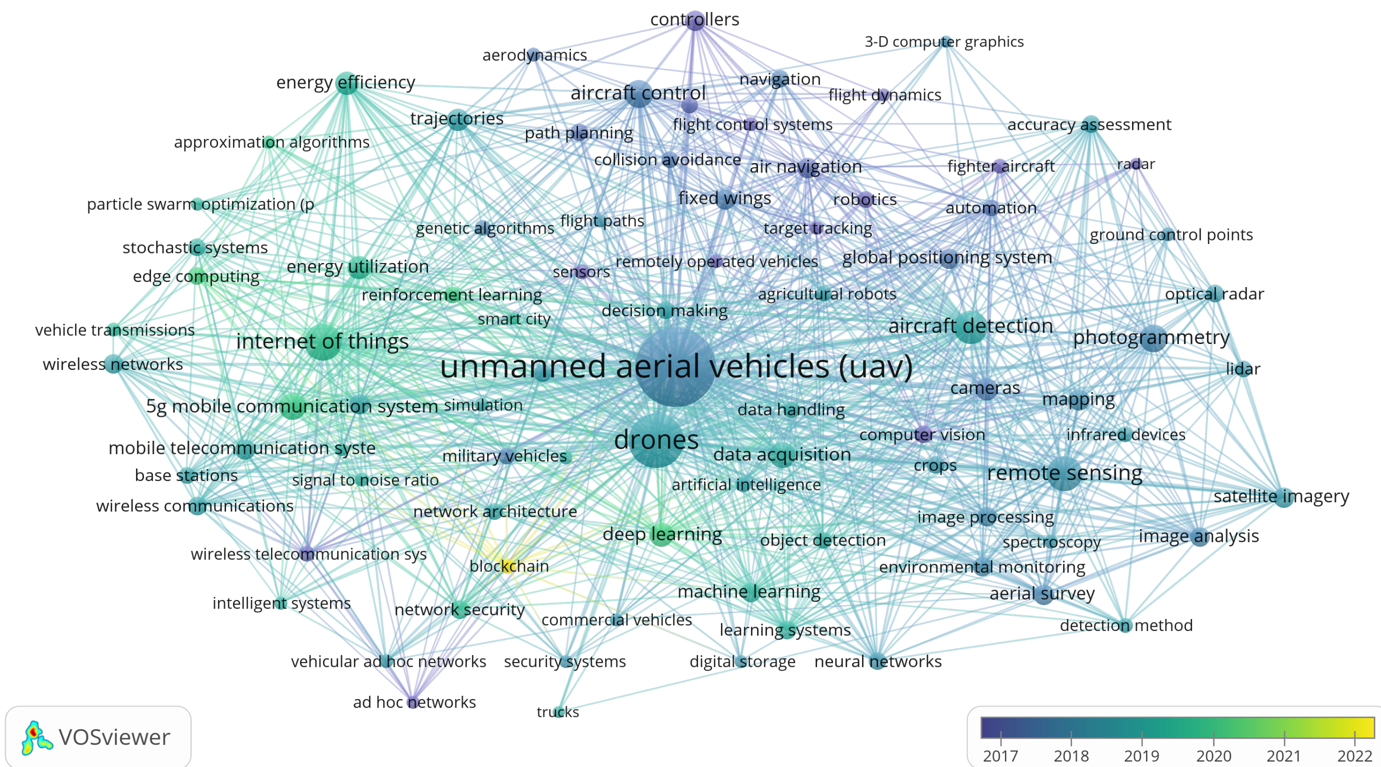

Figure 6: Emerging trends in UAVs.

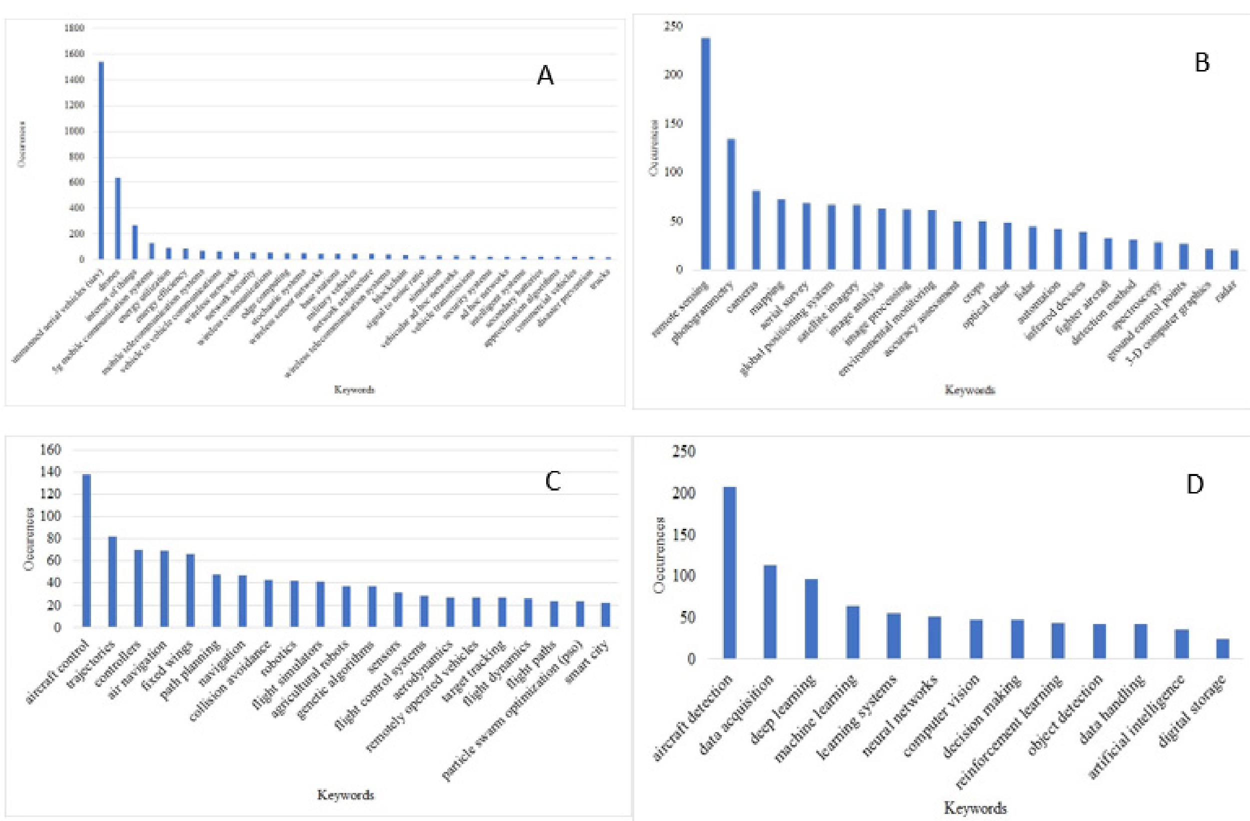

Figure 7: Clusters of UAV Research topics based on aggregated Scopus publications from 2007 to 2022. (A) Cluster-1 (B) Cluster-2 (C) Cluster-3 (D) Cluster-4.

deep learning (11.1%), and machine learning (7.3%), also have a remarkable contribution to the cluster.

Figure 5 displays the most recent and emerging trends in the field of UAV following assessments of the network created using keyword co-occurrences from 2007 to 2022. Based on the typical issue year of each term, a web of keyword co-occurrences is devised using VOSviewer. The nodes exhibit the key phrases for UAV research. The node shades and extent describe the average publishing year, the frequency of term's co-existence, and the linkages between them. The stronger the link between the nodes, the more alike the colors. The keyword co-occurrences are examined to find new trends based on the typical release year.

Figure 6 demonstrates how recent themes can be identified by the nodes coloured in yellow and green with typical publication years of 2022 and 2020. Blockchain, the internet of things, edge computing, 5G mobile communication, reinforcement learning, remote sensing, deep and machine learning, artificial intelligence, and object detection are the newest advances in UAV research. Motion planning, path planning, energy utilization, cameras, and neural networks are the prime focus of UAV research for the typical publication years of 2018 and 2019.

UAV Distributed Processing Applications

This section discusses the applications of distributed processing systems for UAVs with computer science and related field as the centre of consideration.

Navigation

The position of the GPS signal receiver can currently be calculated due to GPS satellites. However, this computation may not be precise enough, or the GPS receiver may not be possible to mount on the UAV. As a result, different navigational options are constantly being considered. The distributed processing routing framework was introduced in, R. W. Deming, *et al*.[51] where the applied algorithms are built on the data from image sensors. The visual information is analysed in a decentralised fashion, and each object is labelled with a signature as a swarm of cars monitors the environment and considers multiple targets. Data from different vehicles are combined to provide a more comprehensive picture of the area. The method described in makes use of numerous base stations that work with UAVs to create a decentralized processing platform.[52]

Detection of Object

UAV swarms use distributed processing to recognize objects based on input from sensors and transponders. Automatic Target Recognition (ATR), another name for this application, heavily makes use of image processing and signal processing technologies. The researchers of [53] demonstrated the dispersed use of Bayesian search. The seeking and positioning algorithm screens numerous readings from the downward-facing mounted cameras to cars. The chance of correct recognition of an object during the target localization process depends on the pixel density and the target's exposure.

Monitoring

Zone monitoring carried out by groups of UAVs is among the most problematic distributed processing operations and is also one of the most perceptive. The monitoring task was carried out by a group of diverse UAVs outfitted with different sensors using dynamic task reconfiguration. Since many jobs demand a significant amount of computing power, making the best use of assets yields the most useful return. Boundary monitoring is a different strategy for the dispersed monitoring system discussed[54] The suggested technique of collaborative boundary monitoring uses a group of UAVs and permits the addition or removal of group members. The findings of the monitoring process are relayed to the base station even though dispersed computing is used.

Tracking

The implementation of tracking is related to object recognition; frequently, the mission objective specifies that the same UAV crew will monitor the object after it has been identified. One program can be used for both object recognition and tracking. The decentralized tracking system's elevated description was provided.[55] The description includes technical information about features, including the vehicle, target monitor, flock steering, and localization, as well as their relationships. Along with potential techniques, the technical specifications and parameters are also supplied.[56] In a search and tracking application sample was provided. The suggested system may transition among searching and tracking modes while still using the data obtained during previous operations. It addresses the case where the monitored object is lost; in this case, the search is repeated, and recursive Bayesian filtering is applied.

Collision Avoidance

As the UAVs function close to one another and certain drones may need to adjust their spatial positions inside the swarm organization, collision avoidance algorithms must be created. Obstruction avoidance and collision avoidance are frequently used interchangeably.[57] In thorough collision avoidance research with scenarios for two autonomous ground vehicles and one unmanned aerial vehicle was provided. The distributed application for UAVs considers that moving objects communicate information about their locations and expected directions of travel with one another. A transmission algorithm keeps these data current so they are available when needed. Because the program is dispersed, each UAV is managed by a different agent that employs various prevention strategies that combine collaborative and non-cooperative techniques.

Environmental Monitoring

The broad research area for single UAV applications is environmental monitoring, accomplished with just one vehicle.[58] The strategy was then expanded to include multi-vehicle solutions.[58] It is suggested that the Centre of Collaborative Mobile Sensing Systems, in collaboration with many colleges, build a distributed system for environmental monitoring. The design components of distributed environment surveillance with a focus on wildfire, polar, and storm are discussed in this paper.[59] Environmental surveillance systems must be implemented in the regions listed below: resilient flying systems, sensor integration, data transformation and visualisation, regulatory regimes, and cooperative direction, positioning, and management.

RESULTS AND DISCUSSION

This study provides an up-to-date analysis of the research publications to assist readers in better understanding the principles of UAVs from 2007 to 2022. It also serves as an initial resource for those unfamiliar with the topic. The methodology used in the present study offers crucial data that can aid scholars regarding publication possibilities, key players (publication origin, organizations, and nations), methods, and the needs and comprehension of UAVs, which calls for knowledge of both practitioners and researchers. The study also highlights the architectural facets of various scientific participants participating in the publication process. Existing theories must be experimentally validated and improved upon to meet the everchanging demands of UAV research. The study uses the Annual Growth Rate (A.G.R) 1 to analyse the growth of the domain over the years, which shows that the area is growing. It has been noted that the study area is constantly growing and has had remarkable growth since 2015. The significance of the publications based on durability over time is determined using the Normalized Citation Impact Index (NCII) 2. The document with the maximum value of NCII has total citations of 497 and is from the journal "IEEE Access" followed by the document with total citations of 944 and is from the journal "IEEE Communications Survey and Tutorials". The influential institutions list the leading institutions in the research domain. It helps list all those institutions where the research has been carried forward with a thrust guiding to find a better place for research activities assistantship. The publication growth shows that this research field will grow more and more for years. It is an emerging area for research and could be considered by new researchers. The latest trends devised by the analysis help the community understand the newest topic of consideration in the research. Blockchain is a trendy topic in UAV research. Nowadays, blockchain is used to improve security more precisely with the help of decentralization and distributed ledger techniques than those legacy methods. So, researchers are working to boost the safety of UAVs using blockchain technology. The prominent journals assist researchers in finding all those editorials which are interested in UAV research. As with many other studies, this one has several drawbacks. Future research should incorporate, among other databases, to track the development of the subject as the study is only focused on publications indexed by the Scopus databases. A descriptive tool that provides details on the most significant publications is the scientometric analysis. Due to the fact that it leaves ambiguous about the context or goal of mentioning or quoting a document, it cannot be utilised as a guide. This study utilizes a VOSviewer as a visualization tool. Future research could employ other visualization tools like Citespace, Bibliometrix, Gephi, etc., for further analysis.

CONCLUSION

The growing applications and studies of UAVs are attracting the attention of researchers everywhere. The UAV study is evaluated to determine its performance from 2007 to 2022 regarding publications' influence, citations, prestigious journals, significant institutions, country partnerships and hot research trends. In this study, the data is visualized using the java-based VOSviewer tool. The research domain includes computer science, earth and planetary sciences, and mathematics. The variety of subject groupings demonstrates the scope of several areas. "The United States" distributes the most periodicals among the 81 nations, followed by "China," "The United Kingdom," "Canada," "Italy," and others. A graphical representation of the correlation among various nations reveals that "China". "The United States," "Canada," and "Italy" are the key UAV research epicentres. Using VOSviewer, the co-occurrence network of UAV terms is created, aiding in identifying current developments. Graphically illustrating the co-occurrence of different UAV keywords. An itinerary analysis reveals that the co-existence lattice represents the latest and most recent trends in UAV research. Blockchain, the internet of things, edge computing, 5G mobile communication, reinforcement learning, remote sensing, deep/machine learning, artificial intelligence, and object detection are among the newest study topics for UAV research. This study applied findings to enhance the researcher's understanding of UAV development, standards, impacts, and forecasts for future research. To extend this research, it may be useful to examine its connections with other scientific areas, such as blockchain, cryptography, and many more.

AUTHORS' CONTRIBUTION

Ajay Kumar: Conceptualization, investigation, writing—original draft preparation, writing—review and editing. Mayank Chopra: Conceptualization, investigation, writing—original draft preparation, writing—review and editing, visualization. Yashwant Singh: Investigation, writing—original draft preparation, writing—review and editing, visualization. Neerendra Kumar: Investigation, writing—original draft preparation, writing—review and editing, visualization. All authors have read and agreed to the published version of the manuscript.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

REFERENCES

1. Nex F, Remondino F. UAV for 3D mapping applications: A review. Applied Geomatics. 2014;6(1):1-15.
2. Sanna A, Pralio B. Simulation and control of mini-UAVs, in Proc. 5th WSEAS Int. Conference on Simulation. 2005.
3. Blyenburgh PV. UAV's-current situation and considerations for the way forward. Development and Operation of UAVs for Military and Civil Applications. 1999.
4. Mingers J, Leydesdorff L. A review of theory and practice in scientometrics. European Journal of Operational Research. 2015;246(1):1-19.
5. Kalita D. The Scientometrics of Nature. Journal Scientometrics Research. 2016;1(5):123-34.
6. Wang M, Liu P, Zhang R, Li Z, Li X. A scientometric analysis of global health research. International Journal of Environmental Research and Public Health. 2020;17(8):2963.
7. Gharib M, Afghah F, Bentley ES. LB-OPAR: Load balanced optimized predictive and adaptive routing for cooperative UAV networks. Ad Hoc Networks. 2022;132:102878.
8. Skondras A, Karachaliou E, Tavantzis I, Tokas N, Valari E, Skalidi I, *et al*. UAV Mapping and 3D Modeling as a Tool for Promotion and Management of the Urban Space. Drones. 2022;6(5):115.
9. Aloqaily M, Jararweh Y, Bouachir O. Trustworthy Cooperative UAV-Based Data Management in Densely Crowded Environments. IEEE Communications Standards Magazine. 2021;5(4):18-24.
10. Wang Y, Zhu H, Zhao Z, Zhang C, Lan Y. Modeling, System Measurements and Controller Investigation of a Small Battery-Powered Fixed-Wing UAV. Machines. 2021;9(12):333.
11. Martín-Béjar S, Claver J, Sebastián MA, Sevilla L. Graphic applications of Unmanned Aerial Vehicles (UAVs) in the study of industrial heritage assets. Applied Sciences. 2020;l0(24):8821.
12. Guan X, Huang Y, Dong C, WU Q. User association and power allocation for UAV-assisted networks: A distributed reinforcement learning approach. China Communications. 2020;17(12):110-22.
13. Sartori D, Yu W. Experimental characterization of a propulsion system for multi-rotor UAVs. Journal of Intelligent and Robotic Systems. 2019;96:529-40.
14. Wu Q, Wang H, Li X, Zhang B, Peng J. Reinforcement learning-based Anti-jamming in networked UAV radar systems. Applied Sciences. 2019;9(23):5173.
15. Albu-Salih AT, Seno SAH. Optimal UAV deployment for data collection in deadline-based IoT applications. Baghdad Science Journal. 2018;15.
16. Zhu Q, Jiang K, Chen X, Zhong W, Yang Y. A novel 3D non-stationary UAV-MIMO channel model and its statistical properties. China Communications. 2018;15:147-58.
17. Zefri Y, ElKettani A, Sebari I, Lamallam SA. Ait Lamallam. Thermal infrared and visual inspection of photovoltaic installations by UAV photogrammetry-Application case: Morocco. Drones. 2018;2(4):41
18. Singh VK, Banshal SK, Singhal K, Uddin A. Scientometric mapping of research on 'Big Data. Scientometrics. 2015;105(2):727-41.
19. Uddin A, Singh VK, Pinto D, Olmos I. Scientometric mapping of computer science research in Mexico. Scientometrics. 2015;105(1):97-114.
20. Bar-Ilan J. Which *h*-index?-A comparison of WoS, Scopus and Google Scholar. Scientometrics. 2008;74(2):257-71.
21. Chadegani AA, Salehi H, Yunus MM, Farhadi H, Fooladi M, Farhadi M, *et al*. A comparison between two main academic literature collections: Web of Science and Scopus databases. 2013. arXiv preprint arXiv:1305.0377, 2013.
22. Hassan SU, Haddawy P, Zhu J. A bibliometric study of the world's research activity in sustainable development and its sub-areas using scientific literature. Scientometrics. 2014;99(2):549-79.
23. Jacomy M, Venturini T, Heymann S, Bastian M. ForceAtlas2, a Continuous Graph Layout Algorithm for Handy Network Visualization Designed for. 2014.
24. Wang W, Lu C. Visualization analysis of big data research based on Citespace. Soft Computing. 2020;24(11):8173-86.
25. Lv H, "Assessment of global law and psychiatry research in the period of 1993-2012: A bibliometric analysis (Part-I). The Electronic Library. 2017;35(3):559-72.
26. Van Eck NJ, Waltman L. Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics. 2010;84(2):523-38.
27. Ozturk GB. Interoperability in building information modeling for AECO/FM industry. Automation in Construction. 2020;113:103122.
28. Serenko A, Bontis N. Meta-review of knowledge management and intellectual capital literature: Citation impact and research productivity rankings. Knowledge and Process Management. 2004;11(3):185-98.
29. Hirsch JE. An index to quantify an individual's scientific research output that takes into account the effect of multiple coauthorship. Scientometrics. 2010;85(3):741-54.
30. Watts AC, Ambrosia VG, Hinkley EA. Hinkley, "Unmanned aircraft systems in remote sensing and scientific research: Classification and considerations of use. Remote Sensing. 2012;4(6):1671-92.
31. Mozaffari M, Saad W, Bennis M, Debbah M. Mobile unmanned aerial vehicles (UAVs) for energy-efficient Internet of Things communications. IEEE Transactions on Wireless Communications. 2017;16(11):7574-89.
32. Mozaffari M, Saad W, Bennis M, Nam Y-H, Debbah M. A tutorial on UAVs for wireless networks: Applications, challenges, and open problems. IEEE Communications Surveys and Tutorials. 2019;21(3):2334-60.
33. Nedić A, Olshevsky A. Distributed optimization over time-varying directed graphs. IEEE Transactions on Automatic Control. 2014;60:601-15.
34. Murray CC, Chu AG. The flying sidekick traveling salesman problem: Optimization of drone-assisted parcel delivery. Transportation Research Part C: Emerging Technologies. 2015;54:86-109.
35. Lyu J, Zeng Y, Zhang R, Lim TJ. Placement optimization of UAV-mounted mobile base stations. IEEE Communications Letters. 2016;21(3):604-7.
36. Alzenad M, El-Keyi A, Lagum F, Yanikomeroglu H. 3-D placement of an unmanned aerial vehicle base station (UAV-BS) for energy-efficient maximal coverage. IEEE Wireless Communications Letters. 2017;6(4):434-7.
37. Li B, Fei Z, Zhang Y. UAV communications for 5G and beyond: Recent advances and future trends. IEEE Internet of Things Journal. 2018;6(2):2241-63.
38. Chen M, Mozaffari M, Saad W, Yin C, Debbah M, Hong CS. Caching in the sky: Proactive deployment of cache-enabled unmanned aerial vehicles for optimized quality-of-experience. IEEE Journal on Selected Areas in Communications. 2017;35(5):1046-61.
39. Chamola V, Hassija V, Gupta V, Guizani M. A comprehensive review of the COVID-19 pandemic and the role of IoT, drones, AI, blockchain, and 5G in managing its impact. IEEE access. 2020;8:90225-65.
40. Dorling K, Heinrichs J, Messier GG, Magierowski S. Vehicle routing problems for drone delivery. IEEE Transactions on Systems, Man, and Cybernetics: Systems. 2016;47(1):70-85.
41. Pajares G. Overview and current status of remote sensing applications based on unmanned aerial vehicles (UAVs). Photogrammetric Engineering and Remote Sensing. 2015;81(4):281-330.
42. Wallace L, Lucieer A, Watson C, Turner D. Development of a UAV-LiDAR system with application to forest inventory. Remote Sensing. 2012;4(6):1519-43.
43. Motlagh NH, Bagaa M, Taleb T. UAV-based IoT platform: A crowd surveillance use case. IEEE Communications Magazine. 2017;55(2):128-34.
44. Zeng Y, Wu Q, Zhang R. Accessing from the sky: A tutorial on UAV communications for 5G and beyond. Proceedings of the IEEE. 2019;107(12):2327-75.
45. Candiago S, Remondino F, De Giglio M, Dubbini M, Gattelli M. Evaluating multispectral images and vegetation indices for precision farming applications from UAV images. Remote Sensing. 2015;7(4):4026-47.
46. Fotouhi A, Qiang H, Ding M, Hassan M, Giordano LG, Garcia-Rodriguez A, *et al*. Survey on UAV cellular communications: Practical aspects, standardization advancements, regulation, and security challenges. IEEE Communications Surveys and Tutorials. 2019;21(4):3417-42.
47. Dandois JP, Ellis EC. High spatial resolution three-dimensional mapping of vegetation spectral dynamics using computer vision. Remote Sensing of Environment. 2013;136:259-76.
48. Yuan C, Zhang Y, Liu Z. A survey on technologies for automatic forest fire monitoring, detection, and fighting using unmanned aerial vehicles and remote sensing techniques. Canadian Journal of Forest Research. 2015;45(7):783-92.
49. Metni N, Hamel T. A UAV for bridge inspection: Visual servoing control law with orientation limits. Automation in Construction. 2007;17(1):3-10.
50. Eck NJV, Waltman L. Visualizing bibliometric networks, In Measuring scholarly impact. Springer. 2014;285-320.
51. Deming RW, Perlovsky LI. Concurrent multi-target localization, data association, and navigation for a swarm of flying sensors. Information Fusion. 2007;8(3):316-30.
52. Rigatos GG. Distributed filtering over sensor networks for autonomous navigation of UAVs. Intelligent Service Robotics. 2012;5(3):179-98.
53. Tisdale J, Ryan A, Zu Kim Z, Tornqvist D, Hedrick JK. A multiple UAV system for vision-based search and localization. In: 2008 American Control Conference. 2008.

54. Chmaj G, Selvaraj H. Distributed Processing Applications for UAV/drones: A Survey. In: Progress in Systems Engineering, Cham. 2015:449-54.

55. Wheeler M, Schrick B, Whitacre W, Campbell M, Rysdyk R, Wise R. Cooperative Tracking of Moving Targets by a Team of Autonomous UAVs. In: 2006 IEEE/AIAA 25th Digital Avionics Systems Conference. 2006.

56. Furukawa T, Bourgault F, Lavis B, Durrant-Whyte HF. Recursive Bayesian search-and-tracking using coordinated uavs for lost targets. In: Proceedings 2006 IEEE International Conference on Robotics and Automation. 2006. ICRA 2006., 2006.

57. Vrba P, Mařík V, Přeučil L, Kulich M, Šišlák D. Collision Avoidance Algorithms: Multi-agent Approach. In: Holonic and Multi-agent Systems for Manufacturing, Berlin. 2007.

58. Harris A, Sluss JJ, Refai HH, PG. LoPresti. Alignment and tracking of a free-space optical communications link to a UAV. In: 24th Digital Avionics Systems Conference. 2005.

59. Argrow B, Lawrence D, Rasmussen E. Rasmussen. UAV Systems for Sensor Dispersal, Telemetry, and Visualization in Hazardous Environments. In: 43rd AIAA Aerospace Sciences Meeting and Exhibit. 2005.

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