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Scholarly Output on Drone Research: A Bibliometric Study

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ABSTRACT

Drones have key applications in surveillance and security, especially in defence. In recent years, drones are also being used in photography, disaster management, traffic tracking, logistics etc. Use of drones in delivery businesses is seen as a progressive opportunity and library system is also not spared from it. A few libraries and book houses are trying to boost their book delivery service by keeping drone as an important mode of delivery, particularly in the remote areas. The time is not far behind when we may find drone as an essential part of our life. Through this study, an effort has made to quantify the research productivity on drone at the global level. The study accommodated publications on drones published from 1968 to 2017 (50 year). The publications related data were retrieved from the Scopus citation index and computed in MS – Excel. Various bibliometric techniques were used to find out the growth rate of publications (16.00 % annually), citation analysis (58.33 % cited rate), authorship pattern and most productive countries etc.

Keywords: Drones, Unmanned aerial vehicles; Measuring research output; Bibliometric study; Citation analysis

1. INTRODUCTION

Broadly, the unmanned aerial vehicles (UAVs) are known as drones. Drones are the small flying robots remotely controlled through the embedded software system. In simple words, the 'drone' is another term for a form of unmanned aircraft which is smaller than any manned aircraft[1]. According to Chao[2], *et al*. the Unmanned Aerial Vehicle represents a power-driven, reusable airplane operated without a human pilot. D'Andrea[3] defined drones as "autonomous or tele-operated flying machines". Generally, the drone popularly nicknamed for unmanned aerial vehicles and micro aerial vehicles[4]. For the last 100 year, small unmanned airplanes played an important role in various warfares taken place across the world. Historically, the use of unmanned air machines had started during the World War-I[5,6]. With the passage of time, application of drones was not limited to wars only but the use of drones has seen as a promising opportunity in various sectors. Today, drones have become an important part of planning in areas of security, surveillance, agriculture, wildlife research, photography, film-making, logistics and disaster management etc. Many public and private companies have been putting their efforts to make extensive use of drones. The delivery drones are the outcome of such research and efforts. The companies like Amazon, Pizza etc have already experimented on delivery drones. Similarly, the use of drones in libraries is also seen as promising opportunity. Drones are expected to offer impetus to library systems in general. The libraries can use drones as a machine to lend and to deliver books to remote locations. In the present scenario, the presence of drones near to people is looking like a fairy tale, that is possible in technical terms, but aviation laws and regulations are yet to address many serious concerns at national or international fronts. In this study, research output on drones is being measured to assess the growth of literature in the areas of drones, authorship pattern, most active researchers, countries and international collaboration.

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2. LITERATURE REVIEW

The first unmanned small aircraft was used about one century ago. Satia[6] explored drone's history and its use in wars. She found that drones are being used since World War-I. These unmanned aerial vehicles (UAVs) have been an important part of political strategies to keep unmanned surveillance by developed countries. She stated that USA governments planted drones in countries of Middle East Asia and shown supremacy in their political ventures. Frequent use of drones was found in the USA. Later, security experts started raising objections on the use of drones within the country as this technology was started troubling the internal security system of USA. Floreano and Wood[4] specified that various public and private research laboratories have been continuously "working on the development of small human-friendly drones that one day autonomously flies in confined spaces and in close proximity to people". They further foresaw technically developed drones that can be used among people with safety and care. They warned that, in near future, the legal aspect to make these drones for extensive public use would be the biggest roadblock for many countries. However, in 2002 Australia became the first country by introducing civilian use of unmanned aerial vehicles through its legislation[7]. In China, the use of personal drones is legal but strictly within the permissible set of aviation

rules only. In the USA, fly unmanned aircraft is also legal but one needs to have remote pilot certificate (RPCI) issued by FFA for making drones' use for personal or commercial purposes.

Nentwich and Harvath[8] stated that many companies have been planning to use drones in the delivery of everyday commodities. The use of drones has enveloped with various technical, societal and regulatory implications. They discussed two potential applications of drones, one is 'Pizza Scenario' where commodities can be delivered to rural or urban areas and second is 'emergency scenario' in which medical aids can be delivered without wasting much time. For implementing drone delivery services, technical feasibility along with safety measures to let these drones fly in the airspace are two important aspects to address. They also shared that at societal front noise pollution and negative aesthetic impact on airspace (that also raised the threat to privacy) are key concerns which are posing a huge threat to use of drones. Villasenor[9] had shown his concern over the drones to eventually fall into the hands of hostile nations and terrorists. However, he also suggested that the technical strength to trace out missing drones, as well as UAVs related regulations at domestic and international level can address this concern to some extent.

Larsen[10] specified that drones are not limited to military use only. The small drones are available for use as a toy or for the hobbyist (photographers or filmmakers). Regev[11] stated that most of the purchases have been started taking place online and consumers want the speedy delivery process of ordered items. This speedy process can only be facilitated by the use of drones. Milhouse[12] stated that the traditional delivery model to deliver goods, in today's scenario, is being considered expensive and wasteful with respect to time and resources. Therefore, the use of drones as delivery vehicles is seen as a progressive opportunity. Howarth[13] reported that the textbook rental company 'Zookal' of Sydney joined hands with Flirtey- which is known as the world's first unmanned aerial vehicle delivery technology. The Zookal has planned to deliver books through Flirtey drones. In this book delivery service, the books will be delivered at the location of a mobile phone instead of the postal address. The service could be available through a mobile app. This could be the first commercial delivery venture of using drones in the world. Desjardins[14] highlighted that Amazon has been testing 'Prime Air' in several international locations to deliver goods to consumers in 30 minutes. Domino's delivered the first pizza by drone in 2016 to a New Zealand couple. Parmar[15] reported that in May 2014, Mumbai became the first city in India to have a pizza delivered by a drone. It was not a sale but a test-delivery done within 3 km from the Pizza outlet. The use of drones for commercial deliveries is not yet allowed in India. However, film-makers and photographers are allowed to make use of drones at an altitude between 200 ft to 400 ft only with various other restrictions. In 2014, it was also reported that Amazon has planned to use drones for product deliveries in Mumbai and Bangalore. Whereas, the Directorate General of Civil Aviation has also announced that in absence of proper rules and regulations the commercial or civilian use of drones is illegal.

Frey[16] shared his perspective and highlighted various use of drones in near future. With respect to libraries, he observed that the library may opt for drones having a big screen on them with live internet connection so that students could have a brief discussion with experts. Steel[17] also shared an idea to use drones in indoor surveillance of a big library. She further expected to use drones within the campus for book deliveries to the faculty in near future. Griffey[1] observed two major use of drones in the libraries. One, use of drones in mapping and searching for information and second utilisation is, the libraries can purchase drones and lend them to users. However, he has shown his concern over copyright or intellectual property rights of the photographs or videos clicked by such drones. Fernandez[18] explored that drones can be made available in libraries for check-out so that public or professionals may have reached to this technology. The agriculture scientist can borrow a drone to monitor the status of their crops and other agricultural aspects. Photographers or film-makers can also borrow drones for better images. He also expected that users of libraries may also get their needed books at their doorsteps (in remote areas as well) with the help of drones. Imam[19], reported about the University of South Florida library is planning to offer students an opportunity to operate drones. The objective of this service to extend library support the students who are working in multimedia projects. Hill[20], shared that Michigan Technological University have been testing the use of drones in accessing the conditions of roads. During the last phase of testing the research team of the university found that the use of drones for assessing the condition of roads is more efficient and less expensive than the manual system. Patil and Nalawade[21], stated that libraries can use the drone for book delivery to the readers who are unable to reach the libraries because of disability or location. Nath[22], pointed out that the book delivery service of libraries can have an added advantage for the people do not have enough time to visit the library or the people living far (location) from the libraries. He specified the term 'Delivery Drone' to describe the UAVs used for delivering packages and also suggested an innovative model for implementation of delivery drone in Indian conditions. Chabot[23], conducted a bibliometric study on UAVs related scientific literature published during 2013-17 and indexed by Web of Science Expanded database. He found steady growth in publications of papers during the period of study. In 2013, the total publications were 544 which is reached to 1593, in 2017. With respect to the subject, the 'engineering' was by far the most prevalent drone research area.

On basis of above-reviewed literature, the use of drones is found in various sectors and community services such as education, security, disaster management, medical emergency and surveillance etc. The libraries are an integral part of educational and community service across the world and use of drones in libraries also seen as an opportunity to enhance the library services. In libraries, the drones are expected to use as a lending service or as a tool for delivering books (check-in/check-out process). In big libraries, drones can also be used as a surveillance tool and retrieval tool to fetch needed books from the stacks. In this bibliometric study, an effort is being made to assess average growth in research output on drones related scholarly output, authorship pattern and assessment of the countries contributing actively in drone research.

3. METHODOLOGY

The study quantifies the scholarly literature published on drones. The data extracted from the Scopus abstract and citation database. Scopus indexes peer-reviewed literature published in all domains of knowledge. The term 'drone' (also accommodating 'drones') was taken and searched in the title, abstract and keyword indexes. For excluding data about drone as fly or honeybee (honey bee) was also taken care of by refining the search string accordingly. The following search string was used for extracting the needed data.

(TITLE-ABS-KEY (drone) AND NOT TITLE-ABS-KEY (drone AND fly) AND NOT TITLE-ABS-KEY (honey) AND NOT TITLE-ABS-KEY (bee) AND NOT TITLE-ABS-KEY (honeybee)) AND PUBYEAR >1967 AND PUBYEAR <2018

The data for 50 year, containing the period from 1968 to 2017 were extracted and computed on MS-Excel. Relevant bibliometric techniques were used for publication or citation analysis. Data were segregated in five block covering ten years in each block for easy representation.

4. DATA ANALYSIS

In total, the world has produced 6600 publication on drones during 1968 to 2017 as per the data extracted from the Scopus database. The document type distribution of these publications accommodated 48.82 per cent (3222) share from conference publications, 36.70 per cent (2422) articles, 3.11 per cent (205) book chapters, 6.20 per cent (409) reviews and remaining 3.42 per cent (518) from other types of documents.

The drone-related publications were analysed in five block periods, covering 50 year from 1968 to 2017. Table 1 represents the total number of publications produced in each block period. A major part of total publications on drones was produced in the last block period (2008-2017), in which the world has produced 5,412 publication (accommodated 82 per cent of total publications).

4.1 Citations with Cited Rate

Table 2 represents the citations received by the drones' related scholarly document during different block periods. The average citations per publication along with cited rate were also highlighted. With respect to total citation, the 5,412 document published during 2008-2017 received 30,544 citations with an average citation rate of 5.64 per document. This block period observed the maximum number of citations among all block periods that somewhere reflects the improved quality and extensive research activities on drone related areas across the world. The lowest average citations per publication were observed during 1978-1987, in which 95 publication received only 380 citation with a 44.21 per cent cited rate.

The maximum cited rate (CR) was observed over the publications produced during 1988-1997. The total of 187 publication received 1006 citation with a 59.89 per cent cited rate. The overall cited rate for 50 year, i.e. 1968-2017 was recorded to 58.33 per cent.

Table 1. Number of publications on drones

Block Period	Total publications	Percent of share
1968-1977	73	01.11
1978-1987	95	01.44
1988-1997	187	02.83
1998-2007	833	12.62
2008-2017	5412	82.00

Table 2. Publications, citations and cited rate

Block	TP	TC	ACPP	CR (per cent)
1968-1977	73	409	5.60	46.58
1978-1987	95	380	4.00	44.21
1988-1997	187	1006	5.38	59.89
1998-2007	833	3632	4.36	57.26
2008-2017	5412	30544	5.64	58.85
Total (1968-2017)	6600	35971	5.45	58.33

TP – Total Publications
TC – Total Citations
ACPP – Average Citations Per Publications (TC/TP)
CR – Cited Rate (% of articles having one or more number of citations)

4.2 Annual Growth Rate

Average Annual Growth rate of drones' related publications was also computed by using the following metrics.

$$Annual\ Growth\ Rate\ (GR) = \left(\frac{\text{Pr}esent\ Publications}{Past\ Publications}\right)^{\wedge} \left(\frac{1}{Number of Years}\right) - 1$$

As reflected in Fig. 1, in the first block period, i.e. 1968-1977, a total of 73 publication were published globally with a 7.18 per cent annual growth rate. In the second block period (1978-1987) only 95 publication were indexed that shows the negative growth of publications in this phase. The third block (1988-1997) the world had published 187 publication with the growth rate of 36.98 per cent annually. The period block of 1998-2007 produced over 833 publication on a 37.97 per cent annual growth rate, whereas, the last block period, i.e. 2008-2017 achieved 7.76 per cent growth rate by publishing 5,412 publication. The average annual growth rate for 50 year (1968-2017) cumulative publications was recorded as 16.00 per cent per year. The analysis also reflects that rapid research activities on drones' related areas were found after the late 1980s.

4.3 Authorship Pattern

The analysis to assess the authorship pattern was also computed. The publications without any authorship (without any author's name) were excluded from the computation. A total of 308 publication were found without representation of any authorship. These non-authored publications were excluded and authorship pattern for 6,292 publication was assessed. It was found the publications published by one author accommodated 25.00 per cent (1573) share of total publications. The single author publication received 3.07 average citations per publications with a 43.42 per cent cited rate. The

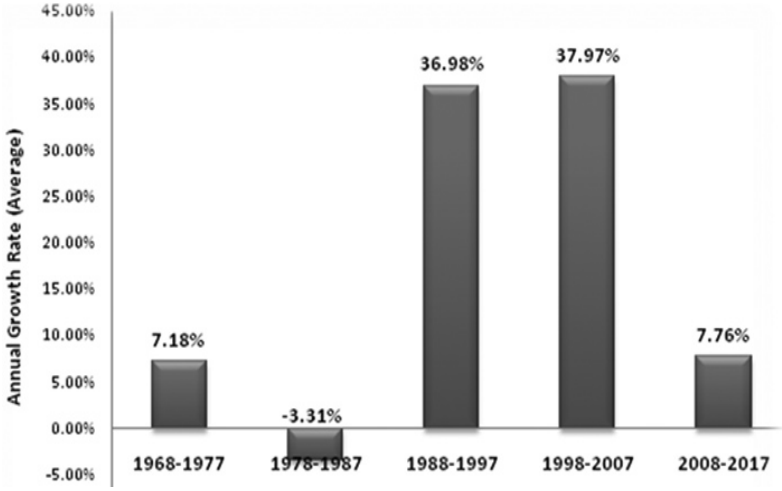

Figure 1. Publications' growth rate.

publications written by two authors hold 19.79 per cent (1245) of publication and achieved 6.04 per cent average citations per publications with a 63.29 per cent cited rate. Publication written by three authors occupied 21.07 per cent (1245) share of total output that received 8246 citation with 66.44 per cent cited rate. Four authored publications accommodated 17.13 per cent (1078) managed 7554 citation at an average of 7.01 citations per publications with 69.94 per cent cited rate. The publication authored by five or more authors captured 17.01 per cent (1070) share that received 7806 citation with an average per publication rate of 7.30 citation and 68.97 per cent cited rate. Fig. 2 represents that quality with respect to citations received and the cited rate increased with the collaboration of multiple authors. More authored publications attract the high number of citations and cited rate as well.

4.4 Degree of Author Collaboration

Collaborated studies are important to bring different thoughts, dimensions and aspects of any study. The author collaboration measured with multiple-authorship publications against single-authorship publications. In this study effort to assess the degree of author collaboration was also made. The degree of author collaboration was computed with a following mathematical formula used by Prof. K Subramanyam[24].

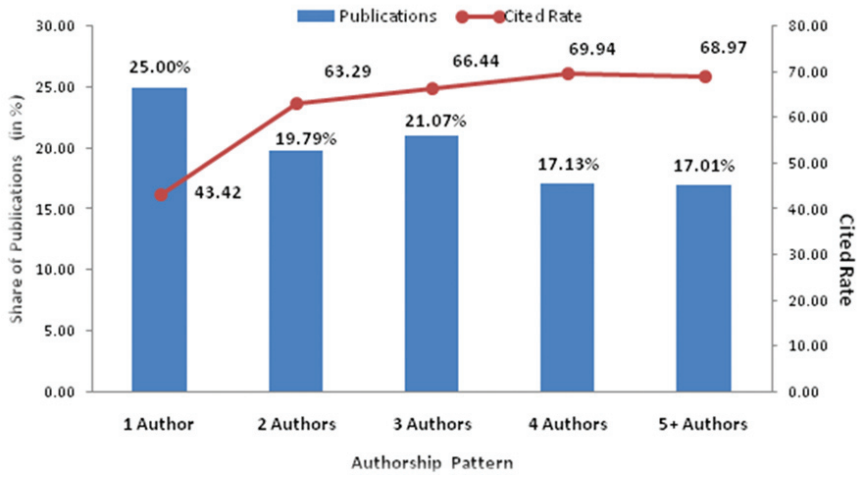

Figure 2. Authorship pattern of drones' publications.

$$Degree\ of\ author\ collaboration\ (C) = \frac{Nm}{Nm + Ns}$$

In this mathematical formula, the degree of author collaboration represented by *C*, multiple authorship represented by *Nm* and single-authorship with *Ns*. On basis of this expression, the block-wise degree of author collaboration was presented in Table 3.

The degree of author collaboration increased in every passing block period, except for the block period 1978-1987. In this block-period the author collaboration was 0.41 which was lowest than the degree of author collaboration 0.49 of 1968-1977. However, the block period 1988-1997 achieved the degree of author collaboration to 0.71, followed by 0.73 in 1998-2007 and 0.76 during 2008-2017. The degree of collaboration for the complete set of 50 year publications was also measured which was reached to 0.76 collectively. The study revealed that multiple-authorship has prevailed more in publications on drones and its related areas.

Table 3. Degree of author collaboration

Block period	Nm+Ns	Nm	Ns	c
1968-1977	73	36	37	0.49
1978-1987	90	37	53	0.41
1988-1997	184	131	53	0.71
1998-2007	778	569	209	0.73
2008-2017	5167	3946	1221	0.76
Total for (1968-2017)	6292	4719	1573	0.75

4.5 Most Prolific Authors

The computation was also made to find out the authors who had written actively on drones. The top ten authors were highlighted who had written ten or more publications on drones. The data revealed that Xu has written maximum numbers of publications, i.e. 20 in numbers, followed by Bao with 19 publication and Hong with 16 publications. The list accommodated six authors from China only. With respect to the number of publications, the top three places are captured by Chinese authors only. The list also envelops two authors from the USA and one each from South Korea and Spain.

Average citations per publication (ACPP) were also measured for all the publications on drones by above-listed authors. It reflected, to some extent, the quality of works as well as how the published works received by the other experts. The table revealed that Campoy of Spain has only written 11 publication on drones but attracted 159 citation with an average rate of 14.45 citation per publications. It shows the publication of Campoy (on drones) were well received by the readers/ researchers. Similarly, Bao of China published 19 publication that achieved 291 citation with an average of 15.32 citation per publication. The table also highlights, that Perrett of China not yet

Table 4. Top ten most prolific authors

Author	Affiliation	Country	TP	TC	ACPP
Xu, J.	Tsinghua University, Beijing/ Radar Academy of Airforce	China	20	108	5.40
Bao, Z.	Xidian University	China	19	291	15.32
Hong, W.	Chinese Academy of Sciences	China	16	181	11.31
Kim, H.	Korea University	South Korea	13	40	3.08
Guan, J.	Naval Aeronautical Engineering Institute	China	13	71	5.46
Dornheim, M.A.	Journalist, Aviation week & Space technology	USA	12	25	2.08
Fulghum, D.A.	General Atomics Aeronautical Systems Inc.	USA	11	12	1.09
Wu, Y.R.	Chinese Academy of Sciences	China	11	53	4.82
Perrett, B.	Aviation Week & Space Technology	China	11	0	0.00
Campoy, P.	Centre for Automation and Robotics, CSIC-UPM	Spain	11	159	14.45

Table 5. Top ten quality source titles

Source title and country	TP	TC	CR	ACPP	STIR	Rank
Proceedings of the International Society for Optical Engineering (SPIE) (USA)	409	1581	62.35	3.87	4.75	1
European Space Agency Special Publication (Netherlands)	94	32	18.09	0.34	1.12	5
Lecture Notes in Computer Science including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics (Germany)	90	175	51.11	1.94	1.43	3
Jane's Defence Weekly (UK)	79	7	8.86	0.09	0.88	8
Aviation Week and Space Technology (USA)	61	47	31.15	0.77	0.93	7
Journal of Electronics and Information Technology (China)	54	190	81.48	3.52	1.39	4
IEEE Transactions on Geoscience and Remote Sensing (USA)	53	2450	100.00	46.23	1.99	2
Jane's Missiles and Rockets (UK)	43	0	0.00	0.00	0.43	10
Proceedings of the International Astronautical Congress IAC (USA)	41	7	7.32	0.17	0.48	9
Systems Engineering and Electronics (China)	38	69	65.79	1.82	1.06	6

received any citation on his 11 publication, though he has been active in writing on drones.

4.6 Source Title Impact Ratio

All these 66,00 publication were accommodated by over one thousand sources. An effort was made to highlight the ten most impactful source titles by assessing source title impact ratio (STIR). The STIR highlights the source titles in which drones related publications were highly published and referred by readers. The STIR is measured on the basis of the following metric.

$$\text{Source title impact ratio (STIR)} = \frac{TP+CR+ACPP}{100}$$

The TP is to highlight the total publications accommodated by the source title. CR reflects the cited rate so that average on referred or non-referred publications can also be accommodated. The ACPP is to assess average citations per publication to incorporate quality aspect.

Table 5 highlights the list of ten top source titles which accommodated more number of publications on drones. On basis of above formula, the STIR for each source was also computed and rank with respect of most promising source accommodated drones related publications were also given. The table shows that *Proceedings of the International Society for Optical Engineering (SPIE)*, an USA publication, achieved 4.75 STIR points and holding the first rank. The proceedings has published 409 publication which attracted 1581 citation with the average citations rate of 3.87 and 62.35 cited rate. *IEEE Transactions on Geoscience and Remote Sensing* again an USA publication achieved the second rank by achieving 1.99 STIR point. The *Jane's Missiles and Rockets*, a source title of UK captured the tenth spot. This journal has published 43 publication on drones were never got cited. On basis of total publication (43) only, the journal accommodated 0.43 STIR points and placed at tenth rank in the list.

4.7 Most Productive Country

Table 6 shows a list of most productive countries that had written the number of publications on drones and related areas. The United States of America (USA) has published 1623 publication. These publications attracted 11894 citations with an average of 7.33 citation per publications. The USA has cited rate of 64.57. The USA is followed by China by publishing 1043 publication and achieving 5.80 citation per publication

Table 6. Most productive countries

Country	TP	TC	CR	ACPP
United States of America	1623	11894	64.57	7.33
China	1043	6046	71.14	5.80
United Kingdom	398	2741	64.07	6.89
Germany	350	2620	68.57	7.49
Italy	325	2731	69.23	8.40
France	315	2813	60.95	8.93
South Korea	235	724	57.02	3.08
Australia	178	1622	68.54	9.11
Canada	174	1857	68.39	10.67
Japan	171	780	56.14	4.56
Spain	131	1668	67.94	12.73
India	129	325	60.47	2.52

with a 71.14 cited rate.

While assessing the quality of publications with respect to achieved citations, Spain published only 131 publication which received 1668 citation with an average of 12.73 citation per publication. It shows the quality of publications were good as compared to others. It was followed by Canada by achieving 10.67 citation per publication. India placed at twelfth position (last in the listed countries) and also achieved the lowest average of 2.52 citation per publication. The Indian research on drones is placed very low as compared to other listed countries.

4.8 International Collaboration

With respect to international collaboration on drones research output, the USA has published maximum numbers of publications, i.e. 378. The USA collaborated with 59 country to publish 23.29 per cent of the total research output on drones. For the USA, China is the most founded country for collaborative research on drone technologies as the USA had published a 11.11 per cent share of its research with China. China is the second most active country that has been experimenting with drone technology. However, China collaborated with 29 country for publishing 12.18 per cent (127) share of its drone related research and finding USA as the most favoured country by collaborating for 33.07 per cent research. Table 7, statistically presents, the details of countries (top twelve) published international collaborative studies in the areas of drones. Most of these listed countries preferred to collaborate with the USA. The UK published 56.03 per cent (223) of its research in Drones in International collaboration and 13.90 per cent share with the USA. Spain has found Italy as most favoured nation for international collaboration on drones by publishing 14.29 per cent share of research. India has collaborated internationally for 17.05 per cent of total research publications on drones. In total, India collaborated with 12 country and among these 27.27 per cent publications published in collaboration with the UK only.

Spain is found to be most active for research sharing at international level as 64.12 per cent of its total research publications on drones were published under international collaboration. France also collaborated for 61.90 per cent of its total drones' related research publications. China (12.18 per cent), South Korea (16.17 per cent) and India (17.05 per cent) are the countries that yet to collaborate for drone technology at the international level. Security and low-expertise are amongst the reasons for internationally not collaborating for research.

4.9 Prevalent Drone Research Areas

The efforts were also made to find out the subject areas in which drone research has actively taken place across the world. Table 8 highlights the top five subject areas prevalent for drone research.

Table 7. International collaboration

Country	Total publications	International collaboration	No. of Countries collaborated	% International collaboration	Most collaborative country	
					Name	% Share of collaboration
USA	1623	378	59	23.29	China	11.11 (42)
China	1043	127	27	12.18	USA	33.07 (42)
UK	398	223	50	56.03	USA	13.90 (31)
Germany	350	198	44	56.57	USA	9.60 (19)
Italy	325	150	31	46.15	USA	20.00 (30)
France	315	195	46	61.90	USA	12.82 (25)
South Korea	235	38	13	16.17	USA	47.37 (18)
Australia	178	101	30	56.74	USA	17.82 (18)
Canada	174	61	21	35.06	USA	24.59 (15)
Japan	171	41	18	23.98	USA	14.63 (6)
Spain	131	84	28	64.12	Italy	14.29 (12)
India	129	22	12	17.05	UK	27.27 (6)

The drone related research has been extensively happening in the 'Engineering' subject. The research publications in Engineering accommodates 45.12 per cent (2978) share of the total publications published on drones and related areas. The second prominent subject area on which drones research was explored is computer science that holds 36.33 per cent (2398) share of total publications. The social science occupies the third most productive subject areas that explored drone research extensively. Social science accommodates 16.68 per cent (1101) part of total drones related publications. The Agriculture and biological sciences are the fourth common subject areas that contained 12.88 per cent (850) portion followed by Physics and Astronomy subject that enveloped 12.41 per cent (819)

Table 8. Prevalent drone research areas

Subject	Publications	Share (per cent)
Engineering	2978	45.12
Computer Science	2398	36.33
Social Sciences	1101	16.68
Agricultural & Biological Sciences	850	12.88
Physics and Astronomy	819	12.41

share of total publications published in drones and related areas. The data indicated that the use of drones is not restricted to engineering or computers only. The social scientists are also exploring to have drones utilisations in various key segments of society including, disaster management, safety, surveillance, education, filming or photography, delivery systems etc. In data, limited entries were found that highlighted the use of drones in libraries. These studies partially experimented on the use of drones in libraries and reported the potential and expectations on basis of such pilot/project studies. However, continuous use of drones in library/libraries has not yet reported by any of the studies.

5. CONCLUSIONS

Most of the researches on drones (unmanned aerial vehicles) were conducted in the last decade. The study determined that multiple authorship patterns were prevailed and more accepted by the readers than the single authorship pattern in publications on drones. The last ten year had produced about 82 per cent of the total publications in drones' related areas. The countries, like the United States of America, China, United Kingdom, Germany and South Korea etc are doing extensive research on drones. India needs to embark upon drones related research areas more strongly. The use of drones is not remained limited to warfares only or to use in defence but the use of drones has emerged as the betterment of public living. Now, security, photography, disaster management, wild-life, logistics etc. are the areas where the use of drones has also started taking place. The delivery of daily needs products has been taken as a promising area and even experimented in some countries.

The libraries are not spared from it as library managers finding drones to act as a delivery tool to deliver documents at remote areas. It has been the biggest challenge to the library managers to bring users into the library and with the help of drones, the libraries are reaching to users. In many countries, especially in developed countries, the civilian use of drones is accepted under strict aviation laws but developing or underdeveloped countries civilian use of unmanned aerial vehicles is still not allowed. However, private ventures such as the Amazon or Pizza have been exploring and experimenting on using delivery drones. The ever developing technology with needed aviation law in each country will soon make it possible to have drones that would expect to fly without hampering security of human beings.

REFERENCES

1. Griffey, J. It just gets weirder. *Libr. Technol. Rep.*, 2012, **48**(3), 25-29.
2. Chao, H.; Cao, Y. & Chen, Y. Autopilots for small unmanned aerial vehicles: a survey. *Int. J. Control Autom. Syst.*, 2010, **8**(1), 36-44. doi: 10.1007/s12555-010-0105-z.
3. D'Andrea, R. Guest editorial can drones deliver? I*EEE Trans. Auto. Sci. Eng.*, 2014, **11**(3), 647-648. doi: 10.1109/TASE.2014.2326952.
4. Floreano, D. & Wood, R.J. Science, technology and the future of small autonomous drones. *Nature*, 2015, **521**(7553), 460. doi: 10.1038/nature14542.
5. Keane, J.F. & Carr, S.S. A brief history of early unmanned aircraft. *Johns Hopkins APL Technical Digest*, 2013, **32**(3), 558-571.
6. Satia, P. Drones: A history from the British Middle East. *Humanity: Int. J. Hum. Rights, Humanitarianism, Dev.*, 2014, **5**(1), 1-31. doi: 10.1353/hum.2014.0002.
7. Moses, A. Here comes the drone age. *The Age.* 2012. https://www.theage.com.au/technology/here-comes-the-drone-age-20120910-25o6p.html (Accessed on 27 October 2018).
8. Nentwich, M. & Horvath, D.M. The vision of delivery drones. TATuP Zeitschrift fur Technikfolgenabschatzung in Theorie und Praxis, 2018, **27**(2), 46-52.
9. Villasenor, J. Here come the drones. *Sci. Am.*, 2012, **306**(1), 16.
10. Larsen, A. Drones in the library: Challenges and opportunities. 2016. doi: 10.7939/R3S17T473.
11. Regev, A. Drone deliveries are no longer pie in the sky. 2018. https://www.forbes.com/sites/startupnationcentral/2018/04/10/drone-deliveries-are-no-longer-pie-in-the-sky/ (Accessed on 24 October 2018).
12. Milhouse, M.O. Framework for autonomous delivery drones. *In* Proceedings of the 4th Annual ACM Conference on Research in Information Technology, 2015, pp.1-4. ACM. doi: 10.1145/2808062.2808075.
13. Howarth, D. World's first drone delivery service launches in Australia. 2013. https://www.dezeen.com/2013/10/16/flying-drones-to-deliver-text-books/ (Accessed on 1 November 2018).

14. Desjardins, J. Amazon and UPS are betting big on drone delivery. 2018. https://www.businessinsider.com/amazon-and-ups-are-betting-big-on-drone-delivery-2018-3?IR=T (Accessed on 28 October 2018).
15. Parmar, T. Drones in India. Need to know column. Center for the study of the Drone at Bard College. 2014. http://dronecenter.bard.edu/drones-in-india/ (Accessed on 28 October 2018).
16. Frey, T. 192 future uses for flying drones. 2014. https://www.futuristspeaker.com/business-trends/192-future-uses-for-flying-drones/ (Accessed on 29 October 2018).
17. Steele, K. Infusing new into the library. *The Bottom Line*, 2014, **27**(4), 129-131.
doi: 10.1108/BL-10-2014-0027.
18. Fernandez, P. Through the looking glass: Envisioning new library technologies drones. *Library Hi. Tech. News*, 2016, **33**(7), 1-5.
doi: 10.1108/LHTN-02-2015-0016.
19. Imam, J. University library to lend drones to students. CNN. 2014. https://edition.cnn.com/2014/06/21/us/college-lends-drones-to-students/index.html (Accessed on 2 November 2018).
20. Hill, D. Researchers have high hopes for drone use in transportation. *Civil Eng. Mag. Archive*, 2014, **84**(4), 38-39.
doi: 10.1061/ciegag.0000661.
21. Patil, R.M. & Nalawade, R.K Innovative technologies to implement at the library of the future. *Int. J. Res. Ideas Innovations Technol.*. 2018, **4**(2). 1249-1251.
22. Nath, F. Library drone delivery programme: A study. *DESIDOC J. Libr. Inf. Technol.*, 2018, **38**(5), 349-353.
doi: 10.14429/djlit.38.5.12892.
23. Chabot, D. Trends in drone research and applications as the Journal of Unmanned Vehicle Systems turns five. *J. Unmanned Veh. Syst.*, 2018, **6**(1), vi-xv.
doi: 10.1139/juvs-2018-0005.
24. Subramanyam K. Bibliometric studies of research collaboration: a review. *J. Inf. Sci.*, 1983, **6**(1), 33-38.
doi: 10.1177/016555158300600105.

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