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RESEARCH ARTICLE

Bibliometric analysis of holographic data storage literature

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Abstract
Objectives. Snapshots of data can be stored in a holographic medium at varying depths. Data can be written via a spiral data channel in spinning holographic media in the form of circular disks like CDs or DVDs. This data is then read by shining a reference beam through the refraction following writing. However, holographic storage is distinct from CD/DVD media in the sense that information is encoded in all three dimensions. Two-dimensional data is written using a single laser beam that spirals around the material. Prototype holographic storage solutions use minuscule cones formed by individual snapshots or pages to store one million pixels. As compared with magnetic disks and tapes, which have a finite lifespan of 50 years at most, the longevity and dependability of optical media storage is advantageous for long-term archiving. Holographic technology allows for the portability of data-intensive media such as broadcast or high-definition video. However, the shelf life of holographic media remains low due to its sensitivity to light. The primary goals of most storage devices are more storage space and faster data transport. Holographic storage devices have the potential to outperform traditional optical storage devices both in terms of capacity and performance. The present paper aims to evaluate the current international research trends in Holographic Data Storage (HDS) and produce a graphical mapping of co-authorship and countries.
Methods. The major outputs of the dataset were authors, document type, publication, institution, nation, and citations. After exporting 1052 data sources, *HistCite* software was used to analyze the citations; visualization mapping was carried out using *VOSviewer* software and R programming language for the analysis of the author-country-title association on Holographic Storage Devices.
Results. The most prominent authors, papers, journals, organizations, and nations in the field of HDS were identified in *HistCite*. Then, four clusters were investigated using *VOSviewer* based on author keywords, citation collaboration networks among different organizations, countries, and the HDS co-authorship network.
Conclusions. During the study period from 2000–2020 (21 years), 4636 authors contributed to 1052 publications. The highest number of publications was in 2009, with a linear adjustment of R^2 = 0.0136. The most prolific author, Lee J., published 3.14% of the articles on this subject. In terms of country distribution, Japan took first-place ranking, claiming 16.54% of the total number of articles. The “holographic” keyword was used in 62.55% of the articles.

Keywords: holographic, data, storage, bibliometric, *HistCite*, *VOSviewer*

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НАУЧНАЯ СТАТЬЯ

Библиометрический анализ литературы по голографическому хранению данных

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Резюме
Цели. Моментальные снимки данных можно хранить на голографических носителях на различной глубине. Они могут быть записаны по спиральному каналу передачи данных на вращающиеся голографические носители в виде круглых дисков, похожих на CD или DVD. После записи данные можно считать через просвечивание опорным лучом при помощи рефракции. В отличие от CD/DVD носителей, в голографических запоминающих устройствах информация кодируется во всех трех измерениях. Двумерные данные записываются с помощью одного лазерного луча, который закручивается по спирали вокруг материала. Для того чтобы сохранить один миллион пикселей, прототипы решений для голографического хранения данных использовали крошечные конусы, образованные отдельными снимками данных или страницами. По сравнению с магнитными дисками и кассетами, срок службы которых ограничен максимум 50 годами, долговечность и надежность оптических носителей информации имеет явное преимущество при долгосрочном архивировании. Голографическая технология обеспечивает переносимость носителей с большим объемом данных, таких как телепрограммы или видео высокой четкости. Однако срок годности голографических носителей остается низким из-за их чувствительности к свету. Основными целями использования большинства устройств хранения данных являются увеличение объема памяти и более быстрая передача данных. Голографические запоминающие устройства потенциально могут превзойти традиционные оптические устройства как по емкости, так и по производительности. Цель настоящей работы – оценить актуальные международные тенденции исследований в области голографического хранения данных и составить графическое отображение соавторства и стран.
Методы. Для анализа была осуществлена выборка данных, в которую вошли авторы, тип, количество публикаций, учреждение, страна, количество и место цитирований. После экспорта 1052 источников данных для анализа цитат использовалось программное обеспечение *HistCite*; визуализация была выполнена с использованием программного обеспечения *VOSviewer* и языка программирования R для анализа ассоциации «автор – страна – название» о голографическом хранении данных.
Результаты. При помощи *HistCite* были определены наиболее значимые авторы, статьи, журналы, организации и страны в области голографического хранения данных. Затем, используя *VOSviewer*, мы исследовали четыре кластера, основанных на авторских ключевых словах, сетях сотрудничества по цитированию между различными организациями, странами, а также сетями соавторов, пишущих о голографическом хранении данных.
Выводы. За период исследования с 2000 по 2020 гг. (21 год) 4636 авторов написали 1052 публикации. Наибольшее количество публикаций было издано в 2009 г. с коэффициентом детерминации R^2 = 0.0136. Наиболее продуктивный автор, Джей Ли, опубликовал 3.14% статей по голографическому хранению данных. С точки зрения распространения по странам первое место в рейтинге заняла Япония с 16.54% от общего количества статей. Ключевое слово «голографический» использовалось в 62.55% статей.

Ключевые слова: голографический, данные, хранилище, библиометрический, *HistCite*, *VOSviewer*

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Прозрачность финансовой деятельности: Авторы не имеют финансовой заинтересованности в представленных материалах или методах.

Авторы заявляют об отсутствии конфликта интересов.

INTRODUCTION

Since the advent of the digital age, the wealth of knowledge available to the general public has grown exponentially. This shift has been largely due to declining data storage costs and the increasing storage capacities of smaller devices. Although capable of satisfying current storage needs, the data storage industry will need to invest in new technologies if it wants to keep up with rising demand. Magnetic and classical optical data storage technologies store bits of information as individual magnetic or optical changes on a recording media. However, both approaches are starting to reach physical limits beyond which it becomes impossible to encode and thus store individual bits. A novel and promising high-capacity option is optical data storage that is distributed through the bulk of a medium as opposed to being limited to its two-dimensional surface. Significant progress toward practical utilization of holographic data storage (HDS) technology due to the recent emergence of cheaper supporting technologies and major findings from various research initiatives, which has generated conceptual breakthroughs [1]. The high density of holographic 3D memories is obtained by superimposing numerous holograms inside the same volume of the recording material. Thus, data storage across three dimensions becomes a practical option for next-generation memory storage [2]. Given the expected development of such systems at a comparable cost with current technology, along with the optimization and standardization of storage media, HDS could one day overtake magnetic and traditional optical data storage solutions as the industry standard for high-capacity data storage [3]. A comparable HDS system can store the equivalent of data from over 1000 CDs, as well as offering benefits over and above those of a traditional storage system. Based on the research collated here, HDS represents a novel three-dimensional data storage system offering significant advantages over conventional read/write memory systems. Some fundamental characteristics of HDS will be discussed along with an examination of potential uses for HDS in modern computing systems. Since the primary focus of this paper is to examine the current state of HDS research around the world, we present a visualization network map to show relationships between authors and their home countries, along with their most frequently used terms, as well as referenced sources and the authors who most frequently cited them.

Brief introduction to holographic data storage

Holographic data storage comprises a high-volume data storage technology that creates holograms of each data instance. Like traditional optical storage devices, it stores high volumes of data in single volume also called 3D Storage [4]. Both write-once and rewriteable holographic media are possible (changes are reversible), the latter using crystal photorefractive impact. The memory architecture is comprised of a blue-green argon laser, beam splitters, reflectors, LCD board, lenses, lithium-niobite crystal, and a charge-coupled device camera. The blue-green argon laser shaft splits into two beams: a signal beam, which goes straight ahead, and a reference beam, which is controlled by a beam splitter. LCD screens reflect signals into lithium-niobite crystals. The reference beam showed crystal from a new angle. When the two beams meet, the signal beam would hologram information [1, 5, 6].

Uses of HDS

Data mining: HDS can be used to identify patterns more rapidly. Large databases with hidden patterns benefit from data mining. However, data mining on PCs places a heavy burden on data storage systems, whereas holographic memory could speed up data mining by improving access and storage [7].

Petaflop operations: a computer's processing speed with HDS is 1000 trillion floating point operations/s. Holographic memory frameworks speed up data access. Holographic memory can handle massive data requirements and be used instead of 10ns DRAM, hard drives, CD ROMs, and rock-mounted petabytes of storage [8].

Benefits of HDS

One terabyte can be stored in holographic memory. Unlike the fastest hard disk, which typically offer data access times of 5–10 ms, data recovery takes place in the microsecond range. For example, HDS can transport

Table 1. HistCite indicators

Ser. No.	Indicator	Definition
1	TLCS/TGCS	All records from an author, source, or other category, or all records, have a total score. TLCS = Total Local Citation Scores. TGCS = Total Global Citation Scores
2	Recs	The number of records where a given item is found is shown in the "number of records" column
3	LCS	The number of citations to work within the collection is represented in the Local Citation Score
4	GCS	The Global Citation Score shows all Web of Science Core Collection citations
5	LCR	Local Cited References shows a paper's reference list's number of collection-wide citations

a film in under a minute and two pages can be compared optically in holographic capacity without data recovery. HDS is also motionless. Thus, mechanical constraints like erosion can be removed [2]. Another advantage of HDS is the ability to recover data from damaged media.

A variety of research frameworks have been proposed for HDS [9, 10]. Various linked applications of HDS analyzed by researchers include digital holograms [11], deep learning [12, 13] modulation code [14], digital watermarking [15], convolutional neural networks [16], and data compression methods [17]. Other research sets out to explore such aspects of HDS as fundamental issues [18], holographic memory [19], and bit error prediction [20], as well as focusing on holographic grating [21], fluid dynamics [22], and optical storage [23]. To the best of the present authors' knowledge, there is no published bibliometric analysis of the holographic data storage literature. As a result, the purpose of the present work is to present a comprehensive bibliometric analysis of HDS studies, indicating current research trends by emphasizing significant research contributions. Our analysis is based on publishing data, citation distributions and statistics, regional and institutional productivity, research topics, impact journals, and keyword frequency. This work will pave the way for future HDS research by outlining research gaps and obstacles in extended storage.

METHODOLOGY

On June 17, 2021, the Web of Science core collection database was accessed alongside a comprehensive web search using the phrases "holographic data storage", "high capacity", "magnetic and optical data storage systems"[1]. The dataset was refined by document type, language, and duplication criteria. Authors, document type, publication, institution, nation, and citations were the major outputs of the dataset. After extracting data from 1052 sources, we used *HistCite*[2] to examine references, *VOSviewer* software[3] to create maps for analysis, and the R programming language to examine the connections between authors, nations, and titles in the Holographic archive. A visualization mapping was produced on the basis of co-authorship country, co-occurrence author keywords, and co-citation cited sources. The process of selecting publications is depicted in Fig. 1.

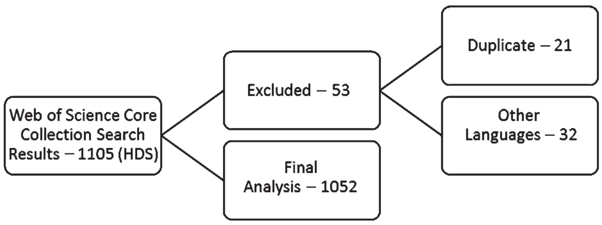

Fig. 1. Holographic data storage publications

Indicators in *HistCite*

The *HistCite* program is used in historiography analysis to organize bibliographic collections obtained by querying the Web of Science's Science Citation Index (WoS). It presents a visual display of the most influential publications on a subject chronology, as well as the evolution of articles, authors, and journals. The current contribution is based on version 12.3. Table 1 lists the *HistCite* indicators [24] employed in this study.

RESULTS

Over the previous 20 years, the number of published papers related to HDS has increased worldwide as shown in Fig. 2. The highest number of publications was 8.56% in 2009; the largest number of worldwide

[1] Clarivate. Web of Science Core Collection. Web of Science Group. 2021. https://clarivate.com/webofsciencegroup/solutions/web-of-science-core-collection/. Accessed July 05, 2021.

[2] Garfield E. HistCite®. *Bibliographic Analysis and Visualization Software*. https://garfield.library.upenn.edu/histcomp/. Accessed July 05, 2021.

[3] Van Eck N.J., Waltman L. *VOSViewer*. (*Visualizing Scientific Landscapes*). 2010. https://www.vosviewer.com. Accessed October 06, 2021.

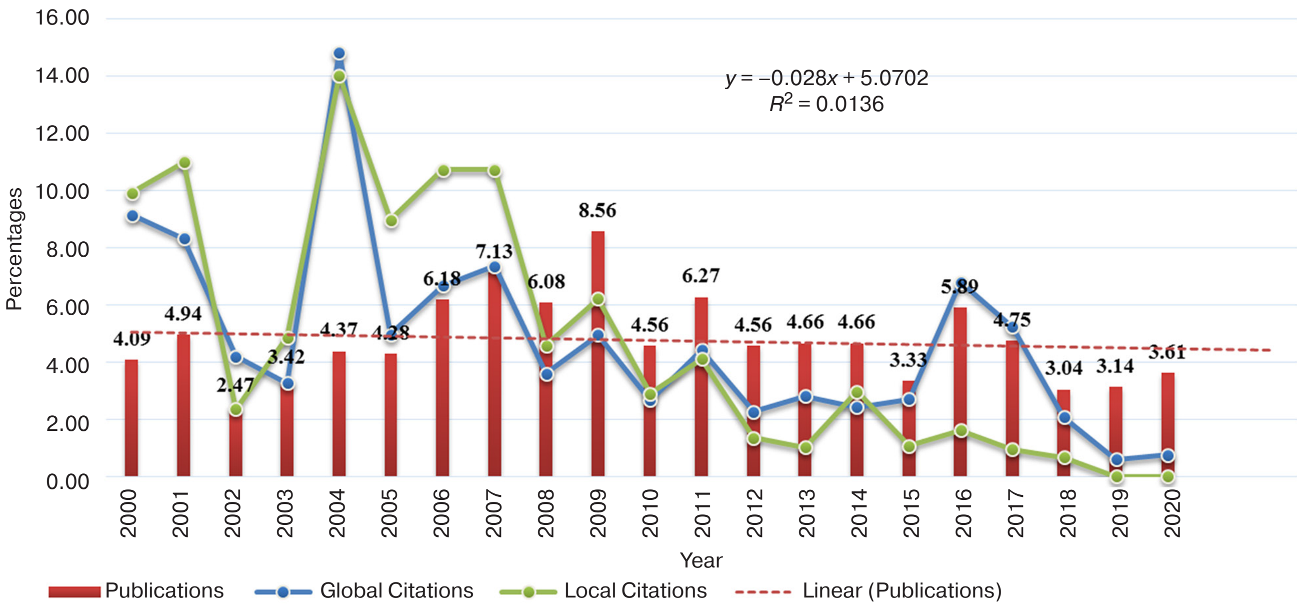

Fig. 2. Growth of HDS publications with citations

citations (14.82%) and local citations (14.03%) occurred in 2004. A linear adjustment of the observed variables $R^2 = 0.0136$ yielded a percentage of average years from the publication of 11.2%, average citations per document of 16.59%, and average citations per year of 1.49%.

As can be seen in Table 2, the 1052 publications had a total of 2236 authors. There were 51 single-authored works and 2185 collaborative works. The most cited author, Lee J., has 33 records (3.14%), a total citation score of 16, and a total citation score of 180 from all over the world. There were two researchers with the highest overall local citation scores: Jin G.F. (29 records, 2.76%) and Yang H. (27 records, 2.57%); their global citation totals were 28 and 260, respectively.

The authorship-collaboration network generated by *VOSviewer* is depicted in Fig. 3. Minimum documents with five authors were chosen for the co-authorship graph approach; of those, 157 met the criteria. A total of 17 authors are evenly distributed throughout four groups (red, green, blue, and yellow). Tan X. has 13 links, 61 total link strength, and 20 documents, making up the majority of cluster-1 co-authorship patterns.

Figure 4 depicts a Sankey diagram of the Authors (left) between Countries (middle) and Titles (right) relationship in HDS literature. The study revealed which titles HDC authors had published most frequently, along with the specific HDS research areas (keywords). An analysis of top authors, titles, and keywords reveal that three authors Lin S.H., Belendez A., and Gallego S., representing the three nations Japan, China, and the United States, had a strong association with the HDS research keywords “holographic”, “storage”, and “data”.

Table 2. Highly productive ten authors on HDS

Ranking	Author	Recs	%	TLCS	TGCS
1	Lee J.	33	3.14	16	180
2	Jin G.F.	29	2.76	28	260
3	Yang H.	27	2.57	4	11
4	Tan X.D.	26	2.47	104	734
5	He Q.S.	25	2.38	25	205
6	Pascual I.	24	2.28	71	387
7	Belendez A.	22	2.09	71	392
8	Cao L.C.	22	2.09	25	210
9	Sheridan J.T.	22	2.09	78	798
10	Ishii N.	20	1.90	10	80

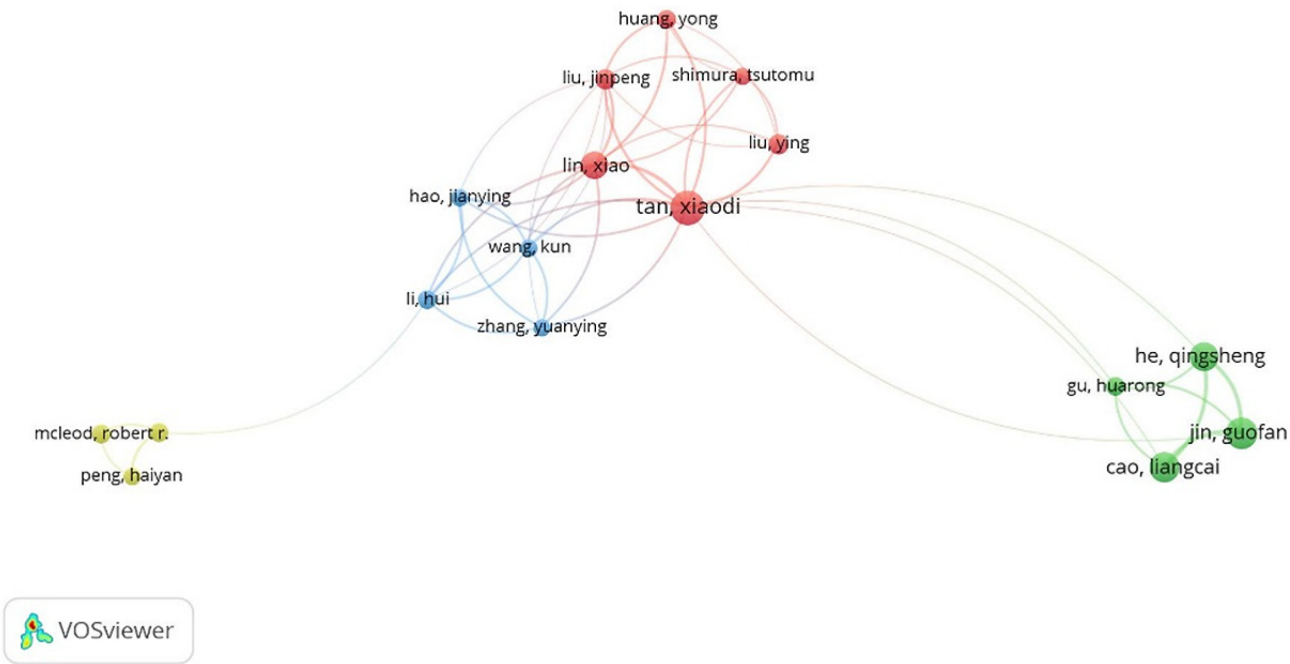

Fig. 3. Co-Authorship network of HDS

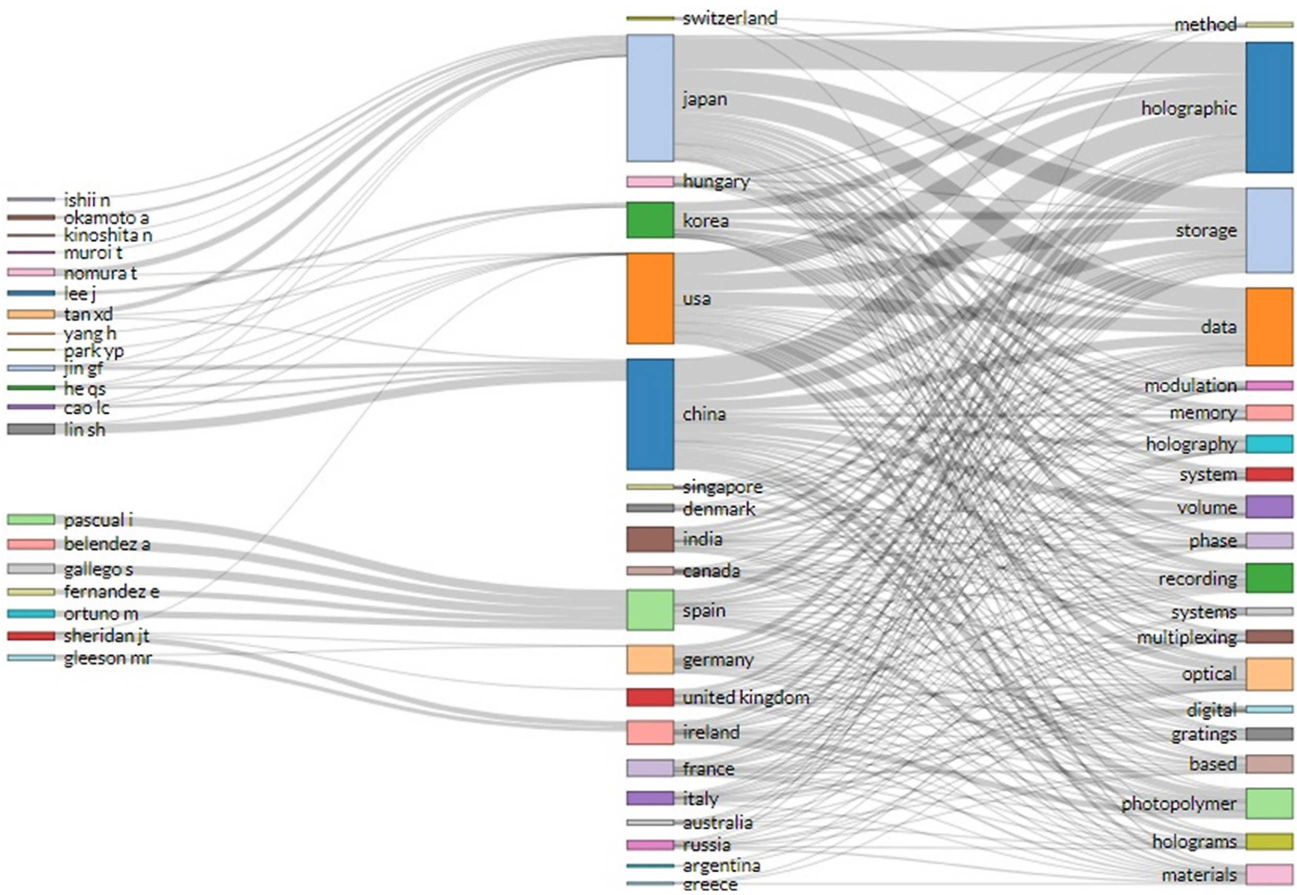

Fig. 4. Sankey diagram displaying the connection between authors (left), countries (center), and titles (right)

Table 3. Distribution of HDS document types

Ser. No.	Document type	Recs	%	TLCS	TGCS
1	Article	960	91.25	1226	13160
2	Proceedings Paper	60	5.70	134	1668
3	Review	27	2.57	100	2460
4	Editorial Material	2	0.19	5	22
5	Review; Book Chapter	2	0.19	2	64
6	News Item	1	0.10	16	79

Table 4. Distribution of HDS records by country

Ranking	Country	Recs	%	TLCS	TGCS
1	Japan	174	16.54	382	3528
2	USA	123	11.69	401	4735
3	China	96	9.13	87	2530
4	Germany	51	4.85	120	2538
5	South Korea	38	3.61	55	789
6	Ireland	31	2.95	108	1169
7	Spain	28	2.66	81	1207
8	UK	27	2.57	67	1431
9	Taiwan	23	2.19	106	548
10	Canada	18	1.71	31	1074

According to Table 3, HDS documents are broken down into six distinct article types, with journals making up the vast majority (91.25%). In total, 1226 HDS documents have a local citation score, while the total number of HDS documents having a global citation score is 13160. There are a total of 16 citations in the local area, and 79 citations in the global arena, making this item the one with the lowest citation score.

HDS publications featured contributions by researchers from 40 different countries. Table 4 covers all countries that contribute to the effectiveness of HDS research publications. Japan tops the list with 174 (16.54%) publications, 382 total local citation scores, and 3528 total global citation scores. It is followed by the United States in second place with 123 (11.69%), 401 total local citation scores, and a total global citation score of 4735, while China is in third place with 96 (9.13%), a total local citation score of 87, and a total global citation score of 2530.

Figure 5 depicts a citation of the countries network graph created using the full counting approach and a minimum of five countries' papers. Only 27 of the 50 countries fit the criteria. Six clusters grouped 26 countries as follows: Cluster 1 (red color, 8 countries)—Belgium, Canada, Denmark, England, Latvia, Netherlands, Poland, and Russia; Cluster 2 (green color, 6 countries)—Bulgaria, Germany, Ireland, Italy, Spain, and Ukraine; Cluster 3 (blue color, 5 countries)—Australia, South Korea, Switzerland, Türkiye, and USA; Cluster 4 (yellow color, 3 countries)—Hungary, India, and Japan; Cluster 5 (purple color, 3 countries)—France, China, and Singapore; Cluster 6 (light blue color, 1 country)—Taiwan.

Overall, 1343 different keywords were used by researchers who contributed to 42 different HDS research publications. Table 5 has 658 (62.55%) documents, the majority of which are holographic studies; the total local citation score for these records is 1031; the total global citation score for these records was 7717; the last position is held by 'System' with 96 (9.13%) records, which have a local score of 130 and a global score of 740. The number of occurrences of the minimum set of five keywords is shown in Fig. 6. In Cluster 7 (orange), the term "Holographic Data Storage" appeared 105 times, was linked 30 times, and had an average link strength of 76.

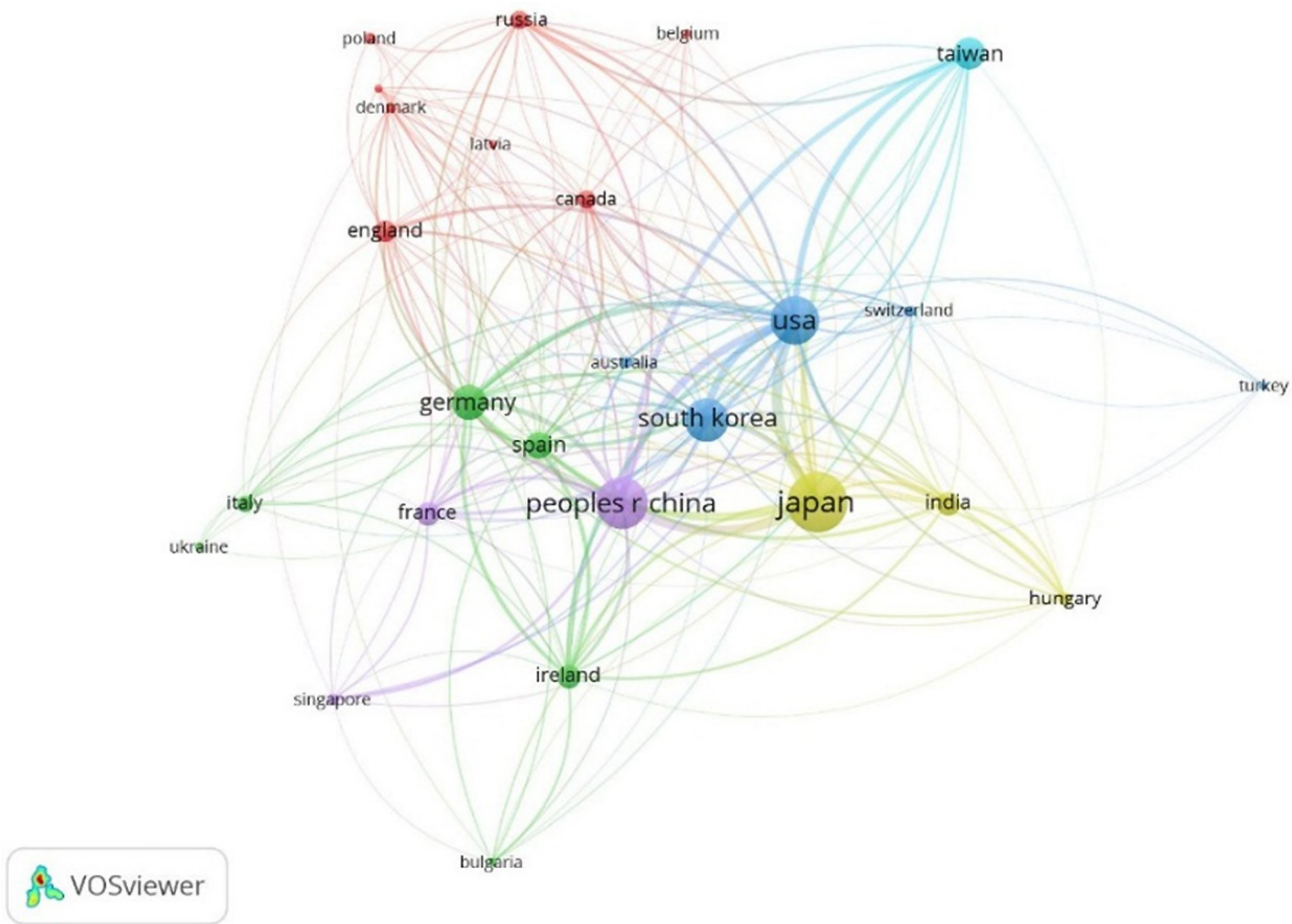

Fig. 5. Citation from different countries on HDS research

Table 5. Predominant author keyword in HDS research

Ranking	Word	Recs	%	TLCS	TGCS
1	Holographic	658	62.55	1031	7717
2	Storage	428	40.68	866	5501
3	Data	397	37.74	775	4722
4	Optical	139	13.21	206	2765
5	Recording	129	12.26	176	1364
6	Using	114	10.84	135	1231
7	Based	104	9.89	113	1763
8	Photopolymer	102	9.70	285	2030
9	Phase	101	9.60	159	1246
10	System	96	9.13	130	740

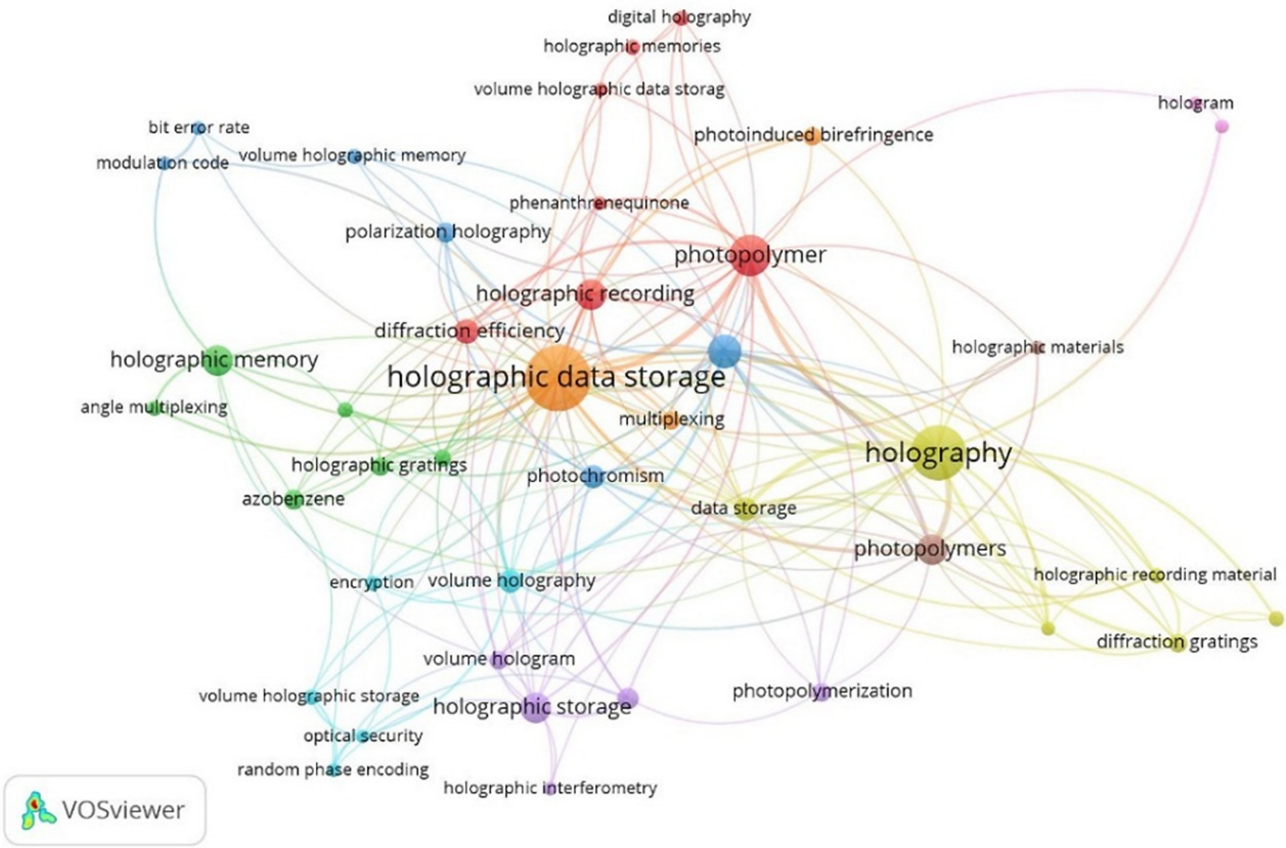

Fig. 6. Author keywords in HDS research

Table 6. Most productive institutions in HDS related publications

Ranking	Institution	Country	Recs	%	TLCS	TGCS
1	University of Alicante	Spain	18	1.71	70	408
2	University College Dublin	Ireland	18	1.71	63	698
3	National Chiao Tung University	China	14	1.33	97	418
4	Tsinghua University	China	14	1.33	18	226
5	Harbin Institute of Technology	China	13	1.24	23	334
6	Sony Corporation	Japan	13	1.24	83	312
7	Beijing Institute of Technology	China	11	1.05	10	258
8	University of Bayreuth	Germany	11	1.05	40	501
9	University of Birmingham	United Kingdom	11	1.05	10	660
10	Wakayama University	Japan	11	1.05	21	516

Table 6 lists the names of 630 different institutions, each of which has contributed to at least five different HDS publications. The list was topped by the University of Alicante in Spain, which had 18 records (1.71%), 70 total local citation scores, and 408 total worldwide citation ratings; University College Dublin was second, with 18 records, 63 total citation scores, and 698 total global citation ratings. Figure 7 depicts the HDS citation cooperation network, which organizes 83 organizations into 7 clusters; here, the "National Chiao Tung University" (Cluster 5, purple) is the most productive citation collaboration organization with 31 publications, 38 links, and a total link strength of 211.

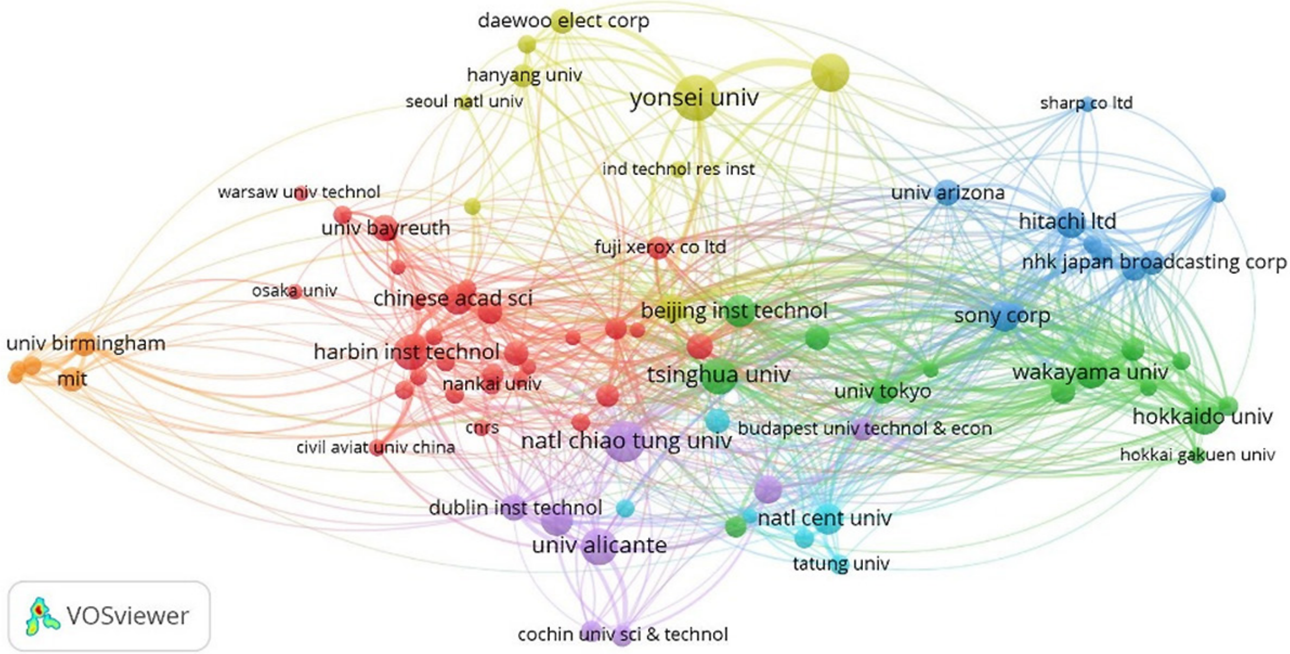

Fig. 7. Citation Collaboration Network of Different Organization in HDS related publications

Table 7. Journal productivity in HDS

Ranking	Journal	Recs	%	TLCS	TGCS
1	Japanese Journal of Applied Physics	119	11.31	22	375
2	Applied Optics	112	10.65	350	2151
3	Optics Express	65	6.18	98	846
4	Optics Communications	48	4.56	67	488
5	Optics Letters	47	4.47	186	1295
6	Japanese Journal of Applied Physics Part 1-Regular Papers Brief Communications & Review Papers	32	3.04	54	213
7	Optical Engineering	30	2.85	41	324
8	Journal of Optics A-Pure and Applied Optics	20	1.90	21	270
9	Optical Review	20	1.90	13	61
10	Microsystem Technologies-Micro-and Nanosystems-Information Storage and Processing Systems	17	1.62	3	12

Table 7 is a list of all peer-reviewed journals that have published at least 15 articles in the last two years. There are a total of 119 published papers (11.31%) published in the Japanese Journal of Applied Physics (1.471 impact factor), which have been cited a total of 22 times locally and 375 times globally. The Applied Optics journal (1.961 impact factor) is in second position with 112 (10.65%) publications, 350 total local citations, and 2151 global citations; Optics Express Journal (3.669 impact factor) is in third place with 65 (6.18%) publications and a total of 98846 global citations.

HistCite graph marker (Fig. 8) exhibited the most cited 50 articles (nodes) with 82 links (relationship among articles by local citation score) with a maximum of 62 and a minimum of 7 citations. These publications had well-integrated citation mapping, implying the notability of published HDS works that referencing them. It can be noted that most citations were made during the first twelve years of the study period (2000 to 2011). A strong separation between one inspired research work (number 182) and multiple linkages was revealed by the *HistCite* citation mapping (numbers 194, 226, 25, and 46). The top five citations are detailed in Table 8.

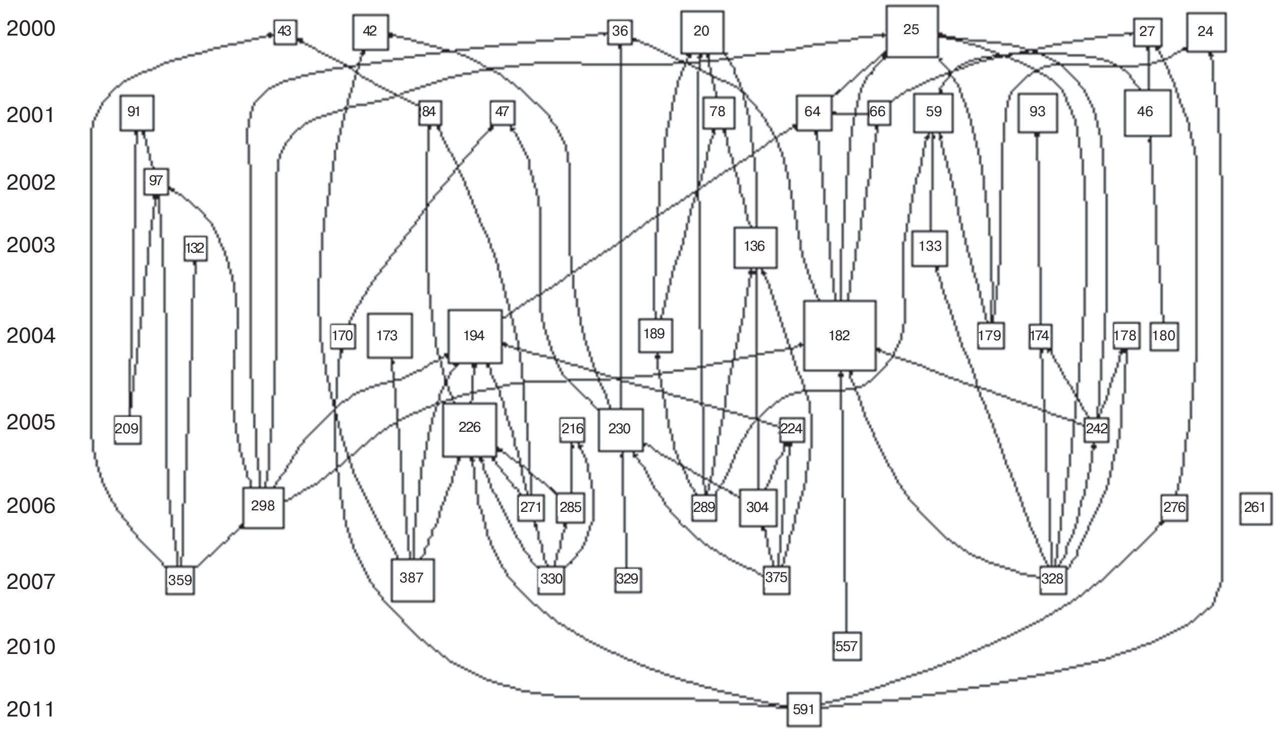

Fig. 8. Total local citation score mapping for HDS

Table 8. Top five citations in HDS

Record	Author	Title	Source	Year	DOI	LCS	GCS
182	Hesselink L., Orlov S.S., Bashaw M.C.	Holographic data storage systems	Proceedings of the IEEE	2004	http://doi.org/10.1109/JPROC.2004.831212	62	258
194	Orlov S.S., Phillips W., Bjornson E., Takashima Y., Sundaram P., Hesselink L., Okas R., Kwan D., Snyder R.	High-transfer-rate high-capacity holographic disk data-storage system	Applied Optics	2004	http://doi.org/10.1364/AO.43.004902	36	135
226	Horimai H., Tan X.D., Li J.	Collinear holography	Applied Optics	2005	http://doi.org/10.1364/AO.44.002575	36	221
25	Ashley J., Bernal M.P., Burr G.W., Coufal H., Guenther H., Hoffnagle J.A., Jefferson C.M., Marcus B., Macfarlane R.M., Shelby R.M., Sincerbox G.T.	Holographic data storage	IBM Journal of Research and Development	2000	http://doi.org/10.1147/rd.443.0341	33	219
46	Lawrence J.R., O'Neill F.T., Sheridan J.T.	Photopolymer holographic recording material	Optik	2001	http://doi.org/10.1078/0030-4026-00091	27	186

The present research employed Local Cited References (LCR), which displays the number of citations in a paper's reference list to other papers in the collection, to predict where the field of holographic data storage is headed. Article rankings according to LCR are displayed in Table 9. A good example is the 26 articles cited by "Holographic polymer materials with diffusion development: principles, arrangement, investigation, and applications" by A.V. Veniaminov and U.V. Mahilny. This suggests that articles using similar data are both highly relevant to the topic and likely to be current articles; moreover, in recent years there have been numerous publications on the topic, resulting in more frequent mentions.

Table 9. Top future direction articles in HDS

Ranking	Record	Author	Title	Source	Year	DOI	LCR
1	750	Veniaminov A.V., Mahilny U.V.	Holographic polymer materials with diffusion development: principles, arrangement, investigation, and applications	Optics and Spectroscopy	2013	http://doi.org/10.1134/S0030400X13120199	26
2	524	Das B., Joseph J., Singh K.	Phase-image-based sparse-gray-level data pages for holographic data storage	Applied Optics	2009	http://doi.org/10.1364/AO.48.005240	19
3	939	Nobukawa T., Barada D., Nomura T., Fukuda T.	Orthogonal polarization encoding for reduction of interpixel cross talk in holographic data storage	Optics Express	2017	http://doi.org/10.1364/OE.25.022425	17
4	921	Malallah R., Li H.Y., Kelly D.P., Healy J.J., Sheridan J.T.	A review of hologram storage and self-written waveguides formation in photopolymer media	Polymers	2017	http://doi.org/10.3390/polym9080337	16
5	591	Bruder F.K., Hagen R., Rolle T., Weiser M.S., Facke T.	From the surface to volume: concepts for the next generation of optical-holographic data-storage materials	Angewandte Chemie-International Edition	2011	http://doi.org/10.1002/anie.201002085	15

CONCLUSIONS

The present article contributes to an understanding of the HDS literature by grouping publications into clusters and identifying new research streams. Using *HistCite*, the study reveals the most prominent authors, papers, journals, organizations, and nations in the field of HDS. Then, using *VOSviewer*, we investigated four clusters based on author keywords, citation collaboration networks among different organizations, countries, and the co-authorship network of HDS. Further, the relationship between authors, countries and titles on HDS literature was established using the R programming language. Finally, the study analyzed the Total Local Citation Score Mapping for HDS, Top 5 citations and subjects of future research on HDS using *HistCite* software. HDS is a new concept that has become a big phenomenon in today's digital world. The most significant issue in the study was that during citation mapping and cluster analysis, only publications having a minimum of seven and a maximum of sixty-two citations were included. Regardless of their proportional contribution, recent papers could not demonstrate their true potential in this manner. Since more than 4.75% of the publications in this study (50 of 1052) were published within the last decade (2000–2011), the bibliometric analysis should be carried out again in the future to recognize new structures having made a mark in the field. Second, non-WoS source databases are not supported by *HistCite*. As a result, this investigation concentrated entirely on WoS publications, yielding articles from respected journals. As a result, there may be a bias against non-WoS journal papers and high-quality publications may present information not found in our study that may sway HDS opinions. It is feasible that future bibliometric software will be created to permit the inclusion of smaller journal publications. Using bibliometric meta-analyses, researchers will be able to compare the construct influences in WoS and non-WoS works, as well as applying them to a wider range of fields.

Authors' contribution

All authors equally contributed to the research work.

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