Understanding the Bibliometric Patterns of Publications in IEEE Access

Raghu Raman¹, Prashasti Singh², Vivek Kumar Singh², Ricardo Vinuesa³, Prema Nedungadi⁵

¹Amrita School of Business, Amritapuri, Amrita Vishwa Vidyapeetham, Kerala 690525, India.
²Department of Computer Science, Banaras Hindu University, Varanasi-221005, India.
³FLOW, Engineering Mechanics, KTH Royal Institute of Technology, Stockholm SE-10044, Sweden.
⁴AI Sustainability Center, Stockholm SE-114 34, Sweden.
⁵School of Computer Science & Engineering, Amritapuri, Amrita Vishwa Vidyapeetham, Kerala 690525, India.

Corresponding author: Raghu Raman (e-mail: ammasraghu@gmail.com).

ABSTRACT The IEEE Access journal started in 2013, and in a short period, it has attained recognition for being a preferred multidisciplinary journal, with characteristics of rapid and continuous publishing. It is now ranked among the top journals in Engineering and Computer Science (General) by Scopus. Recognizing the distinctive nature of the journal and its contributions in the broader area of Engineering and Computer Science, this article attempts to present a detailed bibliometric analysis of the journal to identify publishing patterns, authorship and collaboration structure, citation impact, funding patterns of the published research, and the thematic structure of the publication. The gender distribution is also computed to identify papers published by male and female authors. The social media visibility of the articles and the Sustainable Development Goals (SDG) connections of articles were also identified. The results indicate that the IA journal can attract novel, high-quality multidisciplinary research, which aligns with the relevant and the most pressing SDGs. Furthermore, the journal has experienced increased multi-authored multidisciplinary research, and it is publishing a more significant percentage of articles with female first authors.

INDEX TERMS Bibliometric analysis, citation impact, collaboration structure, gender distribution, IEEE access, thematic structure, sustainable development goals.

I. INTRODUCTION

The Institute of Electrical and Electronics Engineers (IEEE) started publishing—IEEE Access (IA)—a new peer-reviewed, open-access multidisciplinary scientific journal with unique characteristics in 2013. Unlike other traditional journals of IEEE that focus on a specific subject/theme, IEEE Access presents the results of original research and development across all IEEE’s fields of interest. Therefore, it has a multidisciplinary origin. Its hallmarks include a rapid peer review, binary decision of accept or reject, and a continuous publication process with 4 to 6 weeks turnaround time. It uses an APC (Article Processing Charges) based open-access publication model and is now indexed by major journal indexing services, such as Web of Science, Scopus, Dimensions, DOAJ etc.

The IA journal has gained a significant reputation and has emerged as a preferred avenue for submitting quality papers due to its unique characteristics. According to Scopus, IA is ranked in the 81st and 87th percentile on General Computer Science and General Engineering topics, respectively, based on CiteScore. IEEE Access has a Scimago Journal Rank (SJR) of 0.775 (Q1), Source Normalized Impact per Paper (SNIP) of 1.734, and Journal Impact factor (JCR-2020) of 3.367 (Q2). Google Scholar ranks IA 3rd in the top 10 among Engineering and Computer Science (general) journals. It has an h-index of 150 as per the Dimensions database.

Motivated by the emergence of IA as a reputed publication avenue, this article attempts to carry out a bibliometric and analytical study of research publications in IA during 2013–2020. The analysis includes understanding the bibliometric patterns, the gender distribution of contributing authors, social-media visibility of papers, and the thematic structure evident in the documents. A combination of scientometrics, network theoretic, and text analysis-based methodology is used for this purpose. More precisely, the analysis in the paper addresses the following aspects:

- Identify the year-wise research publication volume and patterns in IA,
Understand the authorship and collaboration structure of articles published in IA,
Measure the citation impact of publications,
Identify what amount of research articles in IA have associated funding and from which agencies,
Understand the thematic structure of publications in IA,
Analyze the gender distribution of authors who published in IA,
Measure the social-media visibility of articles published in IA,
Understand connections of research published in IA with the Sustainable Development Goals (SDGs) proposed by the United Nations (UN), and
Identify publications related to COVID-19 research.

The analytical study provides an informative and valuable account of IA’s publication patterns and trends, which helps better understand IA’s focus, reach, and thematic/topical structure. The analysis, thus, presents a comprehensive picture of the bibliometric and other related patterns identified in the IA journal. This is the first such exercise undertaken on IA journal to the best of our knowledge.

The rest of the paper is organized as follows: Section II presents the data and methods used for the analysis. Section III presents the various analytical results on publication patterns (Section III.A), authorship and collaboration structure (Section III.B), citation impact (Section III.C), funding patterns in published articles (Section III.D), thematic structure of publications (Section III.E), the gender distribution of authors (Section III.F), social media visibility of articles (Section III.G), connections of publications with UN SDGs (Section III.H), and research on COVID-19 published in IA (Section III.I). The article concludes with the study’s limitations in Section IV and a summary of significant findings in Section V.

II. DATA & METHODOLOGY
The bibliographic data for this study was obtained from the Dimensions database, a scholarly research-information system provided by Digital Science. It is similar to abstract indexing and metadata providing databases like Scopus (from Elsevier) and Web of Science (from Clarivate Analytics). Dimensions database is known to have more extensive coverage of journals than Web of Science and Scopus [1]. It has been found helpful for bibliometric analysis in various respects [2][7]. Dimensions database provides many useful APIs for performing bibliometric analysis. For obtaining the data for IA journal, the Dimensions database was searched for publication records of IA for the period 2013 to 2020. A total of 44,227 publication records are found indexed in the database. The complete metadata along with cited references and concepts was downloaded from the database for different analyses. A bibliometric study of a journal is a popular approach for identifying the trends of the journal in terms of topics, contributing institutions, authorship structure, highly cited papers etc. Bibliometric analysis approaches are used to perform bibliometric analyses of disciplines [8][15], institutions [16][21], and journals [22][26] etc. The present study uses a combination of standard bibliometric approach, network theoretical approach, and text analysis-based approach for analysis and mapping of IA journal. In addition to computing standard metrics of publication, citations, collaboration, h-index [27] etc., we have also computed the gender distribution of authors in IA, using the Gender API, as applied in Paswan and Singh’s work [28]. The social media visibility of articles published in IA has also been computed by using the standard altmetrics analysis approach, as reported in several previous studies [29][31]. Our study also used Visualization of Similarities (VOS) viewer software [32] to map and visualize the bibliometric data. VOS viewer is a software tool specifically designed for constructing and visualizing bibliometric maps; such science mapping illustrates scientific research’s structural and dynamic aspects. With this software, we demonstrated influence patterns in co-citations [33] and bibliographic coupling [34]. The funding patterns in IA publications were identified by analyzing the acknowledgment section in publication records. The thematic structure of publications, comprising major themes occurring in IA publications and their co-occurrences, were analyzed by processing the keyword and concept field obtained from the database. Finally, the connections of IA publications with UN SDGs and COVID-19 research were identified and reported. Various analytical results are reported in different tables, and figures and results obtained were interpreted in multiple contexts.

A. List of bibliometric Indicators used

- TP: Total number of publications of IA in dimensions database
- TC: Number of times a publication has been cited by other publications in the dimensions database. The values per year are the citations received in each year.
- TC/TP: Total Citations/Total Publications
- h-index: maximum value of h such that the given journal has published at least h papers that have each been cited at least h times.
- TC/Year: Total Citations received in a year
- SJR: SCImago Journal Rank. According to this Rank, prestige is transferred between journals based on their citation links.
- Impact Factor: is calculated as the average of the sum of the citations received in a given year to a journal’s previous two years of publications, divided by the sum of “citable” publications in the previous two year
- TPA: Total publications with Altmetrics Attention Score. It is a weighted count of all the online attention. The values per year represent the years in which the publications were published.
• TPA (%): Percentage of publications with Altmetrics Attention Score

III. ANALYTICAL RESULTS

The analytical results obtained through a combination of Scientometric, network theoretic, and text analysis-based approaches are presented in the following subsections.

A. PUBLICATION PATTERNS AND GROWTH RATE

The IA journal has published 44,227 papers during 2013–20. In Table 1, TP represents Total Publications in a year; AGR represents Annual Growth Rate, and CAGR represents Compounded Annual Growth Rate for all years. Table 1 shows the year-wise number of papers and the growth rate of IA publications since the advent of the journal in 2013 to the year 2020. The yearly number of publications has grown by a factor of 282, rising from 67 publications in 2013 to 17,873 publications in 2020. Since the journal’s beginning, the growth rate of publications in IEEE Access has been high, starting with an AGR of 91.04% from 2013 to 2014. The highest AGR value of 231.27% was recorded from 2016 to 2017, followed by 207.46% growth from 2017 to 2018.

| Year | TP | AGR (%) | CAGR (%) |
|------|----|---------|----------|
| 2013 | 67 | ------  |          |
| 2014 | 128| 91.04   |          |
| 2015 | 259| 102.34  |          |
| 2016 | 858| 231.27  |          |
| 2017 | 2638| 207.46 |          |
| 2018 | 6990| 164.97 |          |
| 2019 | 15414| 120.52 |          |
| 2020 | 17873| 15.95  |          |

Overall, the publications in IEEE Access have grown with a CAGR of 122.12% from 2013 till 2020. One possible explanation for the dramatic growth in publications starting in 2017 might have to do with massive funding support from multiple Chinese govt agencies for open access. The Chinese govt funds over 95% of the studies, agencies. This period also coincides with the starting of the New Chinese Double First-Class University plan funded by the Chinese govt. This is a significant increase in the number of publications for any journal. It can be seen that the rapid and continuous publication model of the journal may be the primary reason for such a high number of publications in the journal.

We next analyzed which countries/regions were the major contributors to the publications in the IA journal. In Table 2, TP represents total publications in a year; TC represents total citations received; Cited % represents % of publications that have received >=1 citation, and TC/TP represents average citation per paper. Table 2 presents the list of top contributing countries in the IA journal from 2013 to 2020. It can be observed that China, the United States, South Korea, the UK, and Saudi Arabia lead the list. Interestingly, China alone accounts for over 60% of the total share of publications, followed by the United States and South Korea with around 9% and 7% of total publications, respectively. This is an interesting observation and agrees with overall growth in publications from China, both in general and in IEEE journals in particular. However, this does not mean that the most influential research comes only from China. In fact, the influence as measured by the citations per publication (TC/TP) shows that Chinese publications are among the least cited. The leader in this respect is India, followed by Canada and the United States.

| Country/Region | TP | TC | Cited % | TC/TP |
|----------------|----|----|---------|------|
| China          | 27343| 214251| 85.33   | 7.84 |
| United States  | 4388| 66180| 89.38   | 15.08|
| South Korea    | 3200| 27611| 85.72   | 8.63 |
| United Kingdom | 2543| 33542| 91.15   | 13.19|
| Saudi Arabia   | 1706| 22417| 92.67   | 13.14|
| Pakistan       | 1562| 18842| 92.64   | 12.06|
| Australia      | 1505| 21019| 90.10   | 13.97|
| Canada         | 1449| 22250| 90.27   | 15.36|
| Spain          | 1349| 12463| 88.88   | 9.24 |
| Taiwan         | 1202| 11306| 86.69   | 9.41 |
| India          | 1137| 19605| 93.32   | 17.24|

We observe that publications from China-based authors and institutions have increased significantly since 2016, rising over 6.5 times between 2015 and 2016. Between 2013 and 2020, the number of publications from China has increased from 4 to 10,191, rising over 2,500 times. While publications from all countries have increased, the rise in the US is around 40 times, for comparison. The Asian countries of China and South Korea exhibit the highest factor of publication growth. It is also interesting to note that there is a particular focus in China to publish in journals that are indexed in Web of Science, which is evident in the publication pattern observed in IA, which shows a very rapid rise from the year when IA’s impact factor was published.

The next analysis involved trying to identify the top contributing institutions to IA journal. The institution affiliation field in data is processed to get an institution-wise count of publications. Table 3 presents the major contributing institutions. It is observed that, out of the top 15 universities with the highest number of publications, 14 are from China. Thus, the Chinese institutions are identified as the most significant contributors to publications in the IA journal, which is in line with the findings reported in Xie and Freeman that highlighted the considerable focus on publishing in China and its impact on the global research ecosystem [35]. In terms
of influence, the single university from Saudi Arabia figuring in the list, King Saud University, has a large number of citations per publication (value of 17.27 for TC/TP) when compared to the value of 10.01 from the University of Electronic Science and Technology of China (UESTC), which has the highest total number of publications. Interestingly, the publications from all these universities have more than 85% of their publications have received at least one citation. This high number of cited articles, especially from Chinese Universities, can be attributed to a focus on quality and influence that the Chinese academic sector has focused on in recent times [36].

### TABLE 3. Top contributing institutions.

| Institution Name                                           | Country | TP  | TC     | Cited % | TC/TP |
|------------------------------------------------------------|---------|-----|--------|---------|-------|
| University of Electronic Science and Technology of China (UESTC) | China   | 963 | 9638   | 87.54   | 10.01 |
| Beijing University of Posts and Telecommunications (BUPT)   | China   | 909 | 9006   | 89.77   | 9.91  |
| Southeast University (SEU)                                 | China   | 847 | 7036   | 86.3    | 8.31  |
| Xidian University                                           | China   | 837 | 7257   | 87.22   | 8.67  |
| Harbin Institute of Technology (HIT)                       | China   | 719 | 6422   | 87.34   | 8.93  |
| National University of Defense Technology (NUDT)           | China   | 700 | 3987   | 83.86   | 5.7   |
| Beihang University (BUAA)                                   | China   | 695 | 5418   | 84.17   | 7.8   |
| South China University of Technology (SCUT)                | China   | 593 | 6049   | 89.21   | 10.2  |
| Northwestern Polytechnical University (NPU)                | China   | 545 | 3815   | 86.97   | 7     |
| Tsinghua University (THU)                                  | China   | 536 | 5366   | 86.75   | 10.01 |
| Zhejiang University (ZJU)                                  | China   | 534 | 4745   | 86.52   | 8.89  |
| Beijing Jiaotong University (BJTU)                         | China   | 533 | 4093   | 88.56   | 7.68  |
| Wuhan University (WHU)                                     | China   | 500 | 3638   | 87.4    | 7.28  |
| King Saud University (KSU)                                 | Saudi Arabia | 493 | 8516   | 94.52   | 17.27 |
| Beijing Institute of Technology (BIT)                      | China   | 487 | 4100   | 86.65   | 8.42  |

### B. AUTHORSHIP & COLLABORATION STRUCTURE

The publication records of IA have been analyzed to calculate the percentage of single-authored and multi-authored papers and to evaluate whether there is a general trend towards multi-authored papers. Figure 1 shows the year-wise trend of authorship. It can be observed that the proportion of single-authored papers has decreased from 2013 to 2020. The majority share of publications is seen coming from papers authored by 2 to 5 researchers. A good proportion of papers are authored by 6–10 authors, a trend that increases with time. This trend is consistent with studies showing a general increase in multi-authored papers [37][38]. The proportion of papers having more than ten authors has decreased and is very low in recent years.

**FIGURE 1.** Proportion of papers with single, 2 to 5, 6 to 10, and 10+ authors.

The most contributors and proficient authors in IA from 2013 to 2020 are also identified in Table 4. The table also provides some citation metrics and indicators for these authors. Based on the total publication number, Lajos Hanzo is the top-contributing author in IA with 129 publications, followed by Mohsen Mokhtar Guizani and Hou-Bing Song with 59 and 52 publications, respectively. While these authors are heavily cited, the citation metric total citation (TC) shows that Mohsen Mokhtar Guizani arguably has the most influence on peer researchers, with 2,498 total citations (TC) for the 69
publications. This is closely matched by Hou-Bing Song, who has a total citation score of 2,102 for a significantly lower count of 59 publications. Hou-Bing Song also holds the highest average citations per article (TC/TP) of 35.63 for the said 59 publications, showing that more peer researchers have relied on Song’s work. Our analysis includes self-citations.

| Name                        | Country          | TP  | TC     | Cited % | TC/TP | h-index |
|-----------------------------|------------------|-----|--------|---------|-------|---------|
| Lajos Hanzo                 | United Kingdom   | 129 | 1821   | 96.90   | 14.12 | 79      |
| Mohsen Mokhtar Guizani     | Qatar            | 69  | 2498   | 98.55   | 36.2  | 68      |
| Hou-Bing Song              | United States    | 59  | 2102   | 96.61   | 35.63 | 52      |
| Guan Gui                   | China            | 52  | 751    | 94.23   | 14.44 | 34      |
| Muhammad Ali Imran         | United Kingdom   | 50  | 1345   | 92.00   | 26.90 | 54      |
| Joel José Puga Coelho Rodrigues | Brazil   | 50  | 933    | 92.00   | 18.66 | 63      |
| Naixue N Xiong             | United States    | 50  | 602    | 88.00   | 12.04 | 44      |
| Xiaojiang James Du         | United States    | 46  | 951    | 95.65   | 20.67 | 48      |
| Sanjeevi Kumar Padmanaban  | Denmark          | 46  | 945    | 95.65   | 20.54 | 32      |
| Zhi Wu Li                  | China            | 45  | 345    | 97.83   | 7.67  | 55      |
| Neal NaixueXiong           | United States    | 45  | 638    | 91.11   | 14.18 | 29      |
| Lei Shu                    | China            | 44  | 2097   | 95.45   | 47.66 | 50      |
| Mohammed-Slim Alouini      | Saudi Arabia     | 43  | 744    | 95.45   | 17.30 | 77      |
| Frede Blaabjerg            | Denmark          | 43  | 884    | 97.67   | 20.56 | 128     |
| Zhu Han                    | United States    | 42  | 534    | 85.71   | 12.71 | 87      |

Overall, data relating to the authorship analysis of IA articles show that this journal has successfully attracted a significant number of articles from top-performing and influential international scholars. For example, Hanzo, Guizani, and Blaabjerg are identified as prolific and collaborative authors by a number of studies [39][40]. Additionally, IA has managed to attract authors having high h-index, such as Frede Blaabjerg, who is among the 250 most-cited engineers, vice president of Danish academic of technical sciences, winner of global energy prize, and IEEE energy prize, among other recognitions [41] and Lajos Hanzo, who is the former editor in chief of IEEE press and an author of over 18 books related to wireless communication [42]. Clearly, IA has successfully attracted top researchers who have made significant contributions to the field.

To understand the international-collaboration patterns in the publications from the journal, the author affiliation field has been analyzed to identify the extent of international collaboration in articles published in IA. Figure 2 shows the proportion of papers that involve international collaboration as well as those produced domestically. The domestic papers are further categorized under papers from authors of a single institution and papers from authors belonging to multiple institutions of the same country. It can be observed that the proportion of international collaborative papers (ICP) in IA has increased over time, except for a slight decrease in recent years. Overall, about 30% of the papers in IA involve international collaboration. There are studies that have indicated that articles with authors from different countries receive higher mean citation rates [43][44]. The domestic papers involving a single institution constitute the highest proportion, which has more or less remained constant during the whole period. The proportion of papers involving collaboration between authors from different institutions of the same country has increased during the period.
C. CITATION Impact

Citations are an essential metric while measuring the impact of an article and a journal in the scientific community [10], [45]. Therefore, citation metrics—including citation numbers, journal sources—are used in this study to investigate the influence of IA publications and the usage and recognition of the journal in the scientific field. We have computed various citation-related measures to understand the citation impact of papers published in IA.

Table 5 shows that between 2013 and 2018, over 90% of the articles published have received at least one citation (Cited % rising to 98.07% in 2015). A slight decline is observed during 2019. However, in 2020, 76.24% of the published articles were cited. A moderate value for TC/TP was observed during the subsequent years. This trend can partly be due to the recent publication time frame, and the percentage of cited articles in 2019 and 2020 will likely increase over the coming years as annual citation count on articles typically peaks in the third year [46]. It is noteworthy that in the beginning year of 2013, the highest value of average citation per paper (TC/TP) was observed at 88.70 [47].

**TABLE 5.** Citation structure of publications.

| Year | TP    | TC    | Cited % | TC/TP |
|------|-------|-------|---------|-------|
| 2013 | 67    | 5943  | 91.04   | 88.70 |
| 2014 | 128   | 6247  | 93.75   | 48.80 |
| 2015 | 259   | 12049 | 96.91   | 46.52 |
| 2016 | 858   | 28297 | 97.79   | 32.98 |
| 2017 | 2638  | 60499 | 98.07   | 22.93 |
| 2018 | 6990  | 99814 | 96.05   | 14.28 |
| 2019 | 15414 | 128418| 91.66   | 8.33  |
| 2020 | 17873 | 64948 | 76.24   | 3.61  |

Over the 2013–2020 period, IE has 683 (2%), 3563 (8%), 6652 (15%) publications in Top 1%, 5% and 10% Citation Percentiles respectively. Effectively, the journal has not only managed to increase the number of publications, but it has also improved the reach of influential publications, attracting more influential research publications overall. In line with the observations of Winter and Halevi, and Moed, these citation-based indicators indicate that the relevance of IEEE publications has increased over the years [48], [49].

Author Co-citation Analysis (ACA) is a proven analytical method to trace the intellectual structure in scholarly communication and is one specific type of co-citation analysis. When two documents are cited by the same third document, co-citation occurs [50]. Analysis of co-citation relies on the assumption that two papers cited together are highly related [51] and thus should be concentrated in a cluster solution of a visualization map. Figure 3 shows a network visualization resulting from the analysis of the co-citation of authors in IA. The citation threshold was set to a minimum of 50. Nodes or circles represent authors, and links between nodes indicate connections between authors (i.e., by co-citations). The distance between the two authors on the map indicates the relatedness of the two authors in terms of co-citations [52]. Each node is assigned a weight based on how strong its links are. The larger the author's name and the larger the circle, the higher the weight.

Our results show that the largest nodes belong primarily to authors from China. For example, the largest nodes belong to Wang X, Wang J, and Wang Y. All three researchers belong to the Beijing University of Post and Telecommunication. Naturally, collaborations among these authors are also numerous. As indicated by the colors, four major clusters can be identified here. The higher degree of collaboration between authors of the same institutional affiliation is already well documented [53] and attributed to higher interpersonal connections and pure physical proximity. It is also evident here with collaborations between all prominent researchers from the Beijing University of Post and Telecommunication.

Similarly, X Li is from North-western Polytechnical University, Xi’an, China. Multiple significant players with collaboration links are from institutes of similar standing from the same geographic region. This observation aligns with the findings reported in Stephens and Cummings, where a much higher chance of collaboration among researchers in the same geographical area was documented [54].
We have also identified the most cited articles of IA during 2013–20. Table 6 provides a list of the 15 most cited IA articles where TC stands for Total Citations and TC/Year stands for citations per year. All 15 influential publications fall within the top 10% of most-cited publications worldwide. The most cited articles may be expected to be the oldest, as it is likely that more researchers would cite the article over time. However, no such trend is observed. Only one article from 2013 made it to the list of the most cited articles. This most cited article with 4,178 citations in total is titled “Millimeter wave mobile communications for 5G cellular: It will work!” It is also exceptional in its influence as it has the highest number of annualized citations among the top-cited articles, 596.86 citations per year. The highest number is 458.5 citations per year for an article published in 2016. An article from 2018 also made it to the list, with 499 citations and 249.5 citations per year. This increase in the presence of recent highly cited articles attests that IA has attracted more and more influential contributions over the years. It is assumed that upcoming areas such as IoT and 5G technology are frequently the topics involved, as they are of critical importance and popularity in the field. This is in line with the findings of Pan et al., which identified wireless 5G communication and millimeter waves as highly popular in 2019 [55]. Similarly, Li and Ho have reported the increased relevance of publications related to IoT [56]. This further attests to the ability of IA to attract relevant publications.

For a more detailed representation of the citation structure of IA, we have created a journal-level citation network for the papers appearing in IA. Figure 4 presents the journal-level citation network, where each node represents a journal, and each represents a citation from one journal to another—in this case, to papers in IA. Of the clusters presented in Figure 4, it can be seen that wireless communication, power grid, power electronics, artificial intelligence, etc., form major groups from which IA publications attract citations. IA looks to have a diverse citation profile, indicating its wider readership and usage. Table 7 shows a tabular list of the top journals citing IA publications ranked by Impact Factor along with their Scimago Journal rank. While preparing this table, we selected only those journals which have impact factors in JCR 2020 and have corresponding SJR 2020. It is observed that IEEE Communications Surveys & Tutorial with SJR 6.6 and impact factor 23.7 has most publications citing IA publications. The overall high SJRs and impact factors of the journals citing IA publications highlight IA publications' relevance to general research.

![Co-citation of IA authors.](image)

**TABLE 6.** Most influential publications.

| Authors | Title | Year | TC | TC/Year |
|---------|-------|------|----|---------|
| Rappaport, Theodore S.; Sun, Shu; Mayzus, Rimma; Zhao, Hang; Azar, Yaniv; Wang, Kevin; Wong, George N.; Schulz, Jocelyn K.; Samimi, Mathew; Gutierrez, Felix | Millimeter Wave Mobile Communications for 5G Cellular: It Will Work! | 2013 | 4178 | 596.86 |
| Author(s) | Title | Year | Pages |
|----------|-------|------|-------|
| Christidis, Konstantinos; Devetsikiotis, Michael | Blockchains and Smart Contracts for the Internet of Things | 2016 | 1834 458.5 |
| Islam, S. M.; Riazul; Kwak, Daehan; Kabir, Humaun; Hossain, Mahmud; Kwak, Kyung-Sup | The Internet of Things for Health Care: A Comprehensive Survey | 2015 | 1381 276.2 |
| Gupta, A.; Jha, R. K. | A Survey of 5G Network: Architecture and Emerging Technologies | 2015 | 1191 238.2 |
| Adadi, Amina; Berrada, Mohammed | Peeking Inside the Black-Box: A Survey on Explainable Artificial Intelligence (XAI) | 2018 | 685 342.5 |
| Hu, Han; Wen, Yonggang; Chua, Tat-Seng; Li, Xuelong | Toward Scalable Systems for Big Data Analytics: A Technology Tutorial | 2014 | 657 109.5 |
| Zhang, Zheng; Xu, Yong; Yang, Jian; Li, Xuelong; Zhang, David | A Survey of Sparse Representation: Algorithms and Applications | 2015 | 610 122 |
| Chen, Xue-Wen; Lin, Xiaotong | Big Data Deep Learning: Challenges and Perspectives | 2014 | 607 101.17 |
| Yin, Chuanlong; Zhu, Yuefei; Fei, Jinlong; He, Xinzeng | A Deep Learning Approach for Intrusion Detection Using Recurrent Neural Networks | 2017 | 571 190.33 |
| Akpakwu, Godfrey Anuga; Silva, Bruno J.; Hancke, Gerhard P.; Abu-Mahfouz, Adnan M. | A Survey on 5G Networks for the Internet of Things: Communication Technologies and Challenges | 2017 | 569 189.67 |
| Parhizi, Sina; Lotfi, Hossein; Khodaei, Amin; Bahramirad, Shay | State of the Art in Research on Microgrids: A Review | 2015 | 559 111.8 |
| Wang, Shuo; Zhang, Xing; Zhang, Yan; Wang, Lin; Yang, Juwo; Wang, Wenbo | A Survey on Mobile Edge Networks: Convergence of Computing, Caching and Communications | 2017 | 506 168.67 |
| Akhtar, Naveed; Mian, Ajmal | Threat of Adversarial Attacks on Deep Learning in Computer Vision: A Survey | 2018 | 499 249.5 |
| Sun, Yunchuan; Song, Houbing; Jara, Antonio J.; Bie, Rongfang | Internet of Things and Big Data Analytics for Smart and Connected Communities | 2016 | 488 122 |
| Basar, Ertugrul; Di Renzo, Marco; De Rosny, Julien; Debbah, Merouane; Alouini, Mohamed-Slim; Zhang, Rui | Wireless Communications Through Reconfigurable Intelligent Surfaces | 2019 | 482 482 |
D. FUNDING PATTERNS IN IA PUBLICATIONS

The publication metadata of the IA papers have been further analyzed to identify how many papers in IA have associated research funding and which are the primary funders. It has been observed that nearly 31% of papers did not acknowledge any specific funding agency. An average of 1.22 funders was reported per paper. Primarily, governments are the primary funding agencies globally. Among the various funding agencies, China takes a significant lead, as we observed that most of the funding agencies are Chinese, as listed in Table 8.

TABLE 8. Top funding sources.

| Funding Sponsor                                             | Supported Publications |
|--------------------------------------------------------------|------------------------|
| National Natural Science Foundation of China (NSFC)          | 19555                  |
| Ministry of Science and Technology of the People's Republic of China (MOST) | 4730                  |
| National Research Foundation of Korea (NRF)                | 1697                   |
| China Postdoctoral Science Foundation                      | 1509                   |
| European Commission (EC)                                    | 1446                   |
| Ministry of Science ICT and Future Planning (MSIP)          | 1413                   |
| Ministry of Education of the People’s Republic of China     | 1282                   |
| Ministry of Science and Technology (MOST)                   | 746                    |
| China Scholarship Council (CSC)                             | 651                    |
| Ministry of Economy, Industry and Competitiveness (MINECO)  | 632                    |
| Chinese Academy of Sciences (CAS)                           | 630                    |
| Engineering and Physical Sciences Research Council (EPSRC)  | 613                    |
| Japan Society for the Promotion of Science (JSPS)           | 465                    |
| Natural Sciences and Engineering Research Council (NSERC)   | 445                    |

These patterns are evident because China has accounted for nearly 60% of publications in IA, and 13 of the top 14 most contributing institutes are based in China. Similarly, there is a
significant representation of Chinese scientists among the top contributing authors to the journal. Among the non-Chinese entities on the list, the National Research Foundation of Korea and the European Commission have sponsored the maximum number of publications. However, the dominance of Chinese government agencies in articles published in IA is significant.

E. THEMATIC STRUCTURE OF PUBLICATIONS

Since IA is a multidisciplinary journal, it has attracted papers from various related disciplines of Engineering, Computer Science etc. To understand the subject area distribution of papers in IA, the Fields of Research (FoR) for each publication, as assigned by the Dimensions database, is identified and analyzed. The FoR classification is a component of the Australian and New Zealand Standard Research Classification (ANZSRC) system and has been adopted by the Dimensions database. The FoR has three hierarchical levels: Divisions, Groups, and Fields. The division represents a broad subject area or research discipline, while Groups and Fields represent increasingly detailed subsets of these categories. There are 22 Divisions, 157 Groups, and 1238 Fields [57].

For the subject area distribution analysis, we have emulated the second level of the system only, Groups. Table 9 below presents the various research fields covered in IA publications and the count of publications and citations for papers in each FoR. As can be observed from the table, Information and Computing Sciences followed by artificial intelligence and then technology are the major fields present. Nearly 75% of total publications and total citations are from Information and Computing Sciences.

To further analyze the contribution from the major FoRs, the number of papers in different publication years from the top contributing FoRs are identified and analyzed. Table 10 shows the number of publications year-wise for the top 5 FoRs. It can be observed that the total publications in the Information and Computing Sciences area rose from 47 in 2013 to 13,841 in 2020, an increase of 284 times. Though the absolute number of publications in AI and Image Processing is relatively less, its growth is over 503 times. Similarly, publications in Communication Technology have increased over 395 times in the same period. This trend highlights the increasing importance of fields such as artificial intelligence and image processing in the IA journal. It may be noted that other reports on AI [58] have also reported that there is a 34.5% growth of AI publications between 2019 and 2020.

### Table 9. Fields of research for IA publications.

| Fields of Research (FoR)                          | TP       | TC       |
|--------------------------------------------------|----------|----------|
| Information and Computing Sciences               | 33295    | 299827   |
| Artificial Intelligence and Image Processing     | 18664    | 171975   |
| Technology                                       | 16177    | 157794   |
| Engineering                                      | 15093    | 113815   |
| Communications Technologies                      | 7525     | 99494    |
| Information Systems                              | 5025     | 66428    |
| Electrical and Electronic Engineering            | 3237     | 33086    |
| Data Format                                      | 2077     | 27502    |
| Computer Software                                | 1429     | 17922    |
| Computation Theory and Mathematics               | 1104     | 10620    |

| FoR/Year                                         | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|--------------------------------------------------|------|------|------|------|------|------|------|------|
| Information and Computing Sciences                | 73%  | 72%  | 73%  | 69%  | 62%  | 83%  | 76%  | 77%  |
| Artificial Intelligence and Image Processing      | 25%  | 29%  | 33%  | 33%  | 30%  | 45%  | 43%  | 45%  |
| Engineering                                      | 55%  | 40%  | 36%  | 29%  | 26%  | 35%  | 35%  | 35%  |
| Technology                                       | 41%  | 52%  | 54%  | 52%  | 42%  | 45%  | 36%  | 34%  |
| Communications Technologies                      | 9%   | 27%  | 35%  | 36%  | 28%  | 25%  | 16%  | 13%  |
For a more detailed understanding and visualization of the thematic structure of publications in IA, we have also created a keyword co-occurrence network and concept density plot for publications in IA. Co-occurrence of keywords can help identify the relevance of an article with regards to specific topics and is linked to precision and recall during searches [59]. VOSviewer software is used to produce the keyword co-occurrence network, which consists of a cluster of nodes of various colors. Nodes having the same colors indicate that they are in the same cluster. Occurrences and weights of the keywords determine the size of the node. The keyword with the biggest circle has the largest weight. The relatedness of the keywords is determined by the distance between the keywords. The shorter the distance, the stronger their relatedness is.

Figure 5 presents the keyword co-occurrence network for publications in IA. We can see that five significant clusters of keywords are identified. Cluster 1 (red color), the largest, contains 92 keywords, cluster 2 (blue color) includes 90 keywords, cluster 3 (yellow color) has 72 keywords, cluster 4 (green color) has 52 keywords, and cluster 5 (pink color) has 3 keywords. These clusters of keywords are clearly linked by topical similarity. For example, deep learning, learning systems, machine learning, among others, fall within the umbrella of methods to mimic learning as a way to create artificial intelligence.

Similarly, the keywords linked to 5G systems such as antennas, bandwidth, etc., cluster together. The linkages between these clusters are also interesting. For genetic algorithms, part of the green cluster dealing with optimization and related methods is also heavily linked to the cluster on learning systems. Similarly, the keyword artificial intelligence and decision-making are linked to deep learning and learning systems. Many such linkages can be identified from Figure 5.

In order to have a more detailed understanding of the themes discussed in IA publications, the database assigned keywords, known as concepts, have been further analyzed and visualized. These concepts are key phrases occurring in the paper and usually represent the themes discussed in the paper. Such concepts are extracted by several machine learning-based approaches used by the database. For each such extracted concept, a relevance score is also assigned. We have identified the 1000 most frequent concepts and plotted a concept density plot in Figure 6. It can be observed that some of the major themes are ‘algorithm,’ ‘network,’ ‘simulation results,’ ‘neural network,’ ‘convolutional neural network,’ ‘images,’ and ‘deep learning.’ Total Link Strength (TLS), which indicates the number of publications in which two keywords occur together, are indicated by yellow, green, and blue colors. The font size of the themes indicates greater TLS and TLS of yellow is > green > blue. We observe that there is a less dispersion of themes with reasonably high degree of connectivity among them, which confirms the interdisciplinary nature of the journal and its focus on contemporary research trends.
F. GENDER DISTRIBUTION OF AUTHORS

The gender distribution of authors contributing to IA is the next topic of analysis. For this purpose, the gender of the first author has been determined by using the Gender-API service. The first name, last name, researcher id, affiliation, and year of publication for all the records was extracted from the publication metadata and analyzed for this task. The author records were then passed to the Gender-API. The Gender-API provides the gender for each record using the first name and country field. Along with the gender, male or female, the accuracy of the assignment is also provided. The Gender-API returned the gender with more than 70% accuracy value. The gender value of these records was then processed to calculate the year-wise gender distribution of authors. Figure 7 shows the year-wise proportion of female and male 1st authored papers. It can be observed that the proportion of female first-authored papers in IA has increased from about 7% in 2013 to approximately 22% in 2020. Thus, there is an overall increase in female 1st authored papers in IA over the 2013–20 period. A similar analysis of top-cited publications in the medical profession showed that 40% of authors were women [60], suggesting a better gender distribution than general engineering. Thus, the gender value for an author with an accuracy value of more than 70% indicates that we used the gender values on which the gender-API returned a value of gender that was more than 70% accurate. Thus, we processed the gender values of first authors of publications that were determined with greater than 70% accuracy and discarded those gender values whose reliability or accuracy was less than 70%.

G. SOCIAL MEDIA VISIBILITY

Typically, citation-based indicators such as impact factor and the number of cited publications make up the bulk of bibliographic studies. However, the alternative field of Altmetrics carries the weight of its own and is a key component of a complete bibliographic analysis [61]. These metrics explore factors such as how often a publication is cited in social media, reference managers, public policy documents, whether mainstream media has covered a publication. Essentially, these metrics provide an alternative way of assessing the significance of an article aside from citations.

To identify the social media visibility of papers published in IA, we have used the altmetrics data integrated into Dimensions and obtained social media coverage data, in different platforms, for those papers from Altmetric.com. It was found that only 14.60% of papers got some social media attention. Table 11 shows % publications with attention for different FoR.

| Table 11: Altmetrics attention of IA publications. |
|---------------------------------|-------|-------|-------|
| Name                           | TP    | TPA   | TPA%  |
| Information and Computing Sciences | 33295 | 2819  | 8.47  |
| Artificial Intelligence and Image Processing | 18664 | 1523  | 8.16  |
| Technology                      | 16177 | 1320  | 8.16  |
| Engineering                     | 15093 | 1097  | 7.27  |
| Communications Technologies     | 7525  | 680   | 9.04  |
| Information Systems             | 5025  | 618   | 12.3  |
| Electrical and Electronic Engineering | 3237  | 232   | 7.17  |
| Data Format                     | 2077  | 223   | 10.74 |
| Computer Software               | 1429  | 202   | 14.14 |
| Computation Theory and Mathematics | 1104  | 107   | 9.69  |
| Materials Engineering           | 974   | 62    | 6.37  |
It is seen that Information and Computing Sciences have a relatively higher number of publications with attention. This FoR also has the highest number of citations, indicating a correlation between the two. Essentially, peers cited fields with greater relevance, and the Web visibility follows a similar trend. It can also be seen that more generic FoR such as computer software and Information systems receive greater attention when Altmetrics are considered. Table 12 shows the platform-wise visibility of 6456 publications in IA, which have Altmetrics attention for the period 2013–2020. The platforms covered are Twitter, Facebook, News, Blog, Wikipedia, and Mendeley. Mendeley has the highest proportion of papers with attention, followed by Twitter and Facebook among different platforms. Mendeley is considered as an Academic Social Network (ASN) platform, which explains the high number of articles (98.43%) covered under it. It is exciting to observe Twitter having good coverage of 40.3%, possibly indicating that academics value sharing their research work via tweets. Other platforms have a very low altmetrics coverage.

We also studied the correlation between citation counts and altmetrics attention scores for the publications between 2017 and 2018. Altmetrics scores showed a weak positive correlation with citation counts ($r = 0.158$). For those two years, there were a total of 8962 publications with citations ranging from 0 to 905 and altmetrics scores ranging from 1 to 190. About 3% of the publications had zero citations, while 89% of the publications did not have altmetrics scores. These results are consistent with the previous studies that publications with altmetrics counts are still very low. Still, these results are insufficient to conclude the publications' quality with no altmetrics score [62][63].

**TABLE 12.** Altmetrics attention of IA publications in different platforms.

| Platform         | Total no. of articles | Coverage (%) | Avg. Mentions/ paper |
|------------------|-----------------------|--------------|----------------------|
| **Twitter**      | 6,456                 | 40.30%       | 4.87                 |
| **Facebook (FB)**| 6,456                 | 4.40%        | 1.65                 |
| **News Mediums** | 6,456                 | 2.85%        | 3.19                 |
| **Blog Platforms** | 6,456               | 1.67%        | 1.17                 |
| **Wikipedia**    | 6,456                 |              | 148                  |

**Mendeley**

| Coverage (%) | Avg. Mentions/ paper |
|--------------|----------------------|
| 98.43%       | 40.70                |

**H. CONNECTIONS WITH SDGs**

The Sustainable Development Goals (SDGs), also known as the Global Goals, were adopted by the United Nations in 2015. There are 17 goals and 169 indicators, with targets to be achieved by 2030. Given the global reach of the goals and their importance to human well-being—including addressing issues ranging from poverty to promoting innovation and fighting climate change—it is understandable that research related to the SDGs is gaining attention [64]. The publication of SDG-related articles has increased in every field ranging from life sciences to arts [65]. There is a proportionate increase in technology publications like the review on AI and the SDGs by Vinuesa et al. [66], and by Gupta et al. [67]; therefore, we tried to find out whether there are publications in IA-related SDGs. The Dimensions database provides an automated classification of publication records into different SDGs based on the content of the article. The Dimensions database provides an automated classification of publication records into different SDGs based on the content of the article. Table 13 shows several publications in IA that relate to different SDGs. It can be observed that SDGs 7 (on clean energy), 13 (on climate action), 3 (on health), and 11 (on sustainable cities) have gained maximum attention in IA publications. The focus on SDG 7 in IA publications can be understood in the context of developing more efficient energy solutions and the associated electric consumption of currently-developed algorithms, which is a highly specialized area. Therefore, it can be inferred that novel technology applications [68] towards achieving the SDGs are most relevant regarding SDGs 7 and 13, and there is a relatively higher emphasis in IA publications on these areas. In particular, there is a very high potential of data-driven methods in the context of sustainable solutions to fight climate change, for instance, optimizing the usage of the available energetic resources [69].

**TABLE 13.** SDG related research in IA

| Name                                         | TP  | TC   |
|----------------------------------------------|-----|------|
| 7 Affordable and Clean Energy                | 6434| 76042|
| 13 Climate Action                            | 699 | 9032 |
| 3 Good Health and Well Being                 | 589 | 7110 |
| 11 Sustainable Cities and Communities        | 322 | 5812 |
| 4 Quality Education                          | 209 | 2062 |
| 10 Reduced Inequalities                      | 92  | 435  |
| 12 Responsible Consumption and Production    | 64  | 1005 |
| 16 Peace, Justice and Strong Institutions    | 64  | 480  |
| 8 Decent Work and Economic Growth            | 52  | 477  |
| 9 Industry, Innovation, and Infrastructure    | 41  | 332  |
2 Zero Hunger 14 422
6 Clean Water and Sanitation 12 54
14 Life Below Water 12 124
1 No Poverty 9 24
15 Life on Land 6 54

The top-5 areas from Table 13 are further analyzed in terms of their publication year, as shown in Table 14. The numbers show an increase in interest in the five SDGs, but sustained and substantial growth is most evident in SDG 7, the relevance of which was discussed above. Perhaps an additional aspect of novel technology related to SDG 7 is the steep increase of electricity consumption associated with formation-and-

TABLE 14. Evolution of SDG related research in IA over years

| UN SDG                              | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|-------------------------------------|------|------|------|------|------|------|------|------|
| 7 Affordable and Clean Energy       | 5%   | 14%  | 20%  | 21%  | 16%  | 17%  | 13%  | 15%  |
| 13 Climate Action                   | 0%   | 0%   | 2%   | 1%   | 1%   | 1%   | 1%   | 2%   |
| 3 Good Health and Well Being        | 2%   | 2%   | 0%   | 1%   | 1%   | 1%   | 1%   | 2%   |
| 4 Quality Education                 | 0%   | 0%   | 1%   | 0%   | 1%   | 0%   | 0%   | 1%   |
| 11 Sustainable Cities and Communities | 0% | 0% | 1% | 1% | 1% | 1% | 1% | 1% |

I. COVID-19 RELATED RESEARCH IN IA

As with any other sector, the recent coronavirus disease 19 (COVID-19) crisis has affected the world of academic publishing in unique ways [71]-[73]. There are publications in IA too that deal with one or the other aspect of COVID-19 research. Table 15 presents the country-wise IA publications related to Covid-19 research. It can be seen that China has the maximum number of articles followed by the US, Saudi Arabia, and the UK. However, most citations are for Australia, India, and the US papers. Interestingly, while just 17 publications from India are identified, as opposed to 50 from China and 49 from the US, these 17 publications have amassed 665 citations, as opposed to 361 for Chinese publications and 622 for those from the US. It implies that the Indian publications received 39.12 citations per publication, followed by 12.69 from publications in the US and 7.22 from the Chinese studies. Similarly, though Australia and the UK have almost similar publications, the citations are significantly higher for Australian publications, nearly 67% more. These numbers show the importance of bibliographic studies in identifying the significance of publications, critical research groups, etc., instead of just assessing the number of publications [74][75].

TABLE 15. COVID-19 related research in IA.

| Name            | TP  | TC  | TC/TP |
|-----------------|-----|-----|-------|
| China           | 50  | 361 | 7.22  |
| United States   | 49  | 622 | 12.69 |
| Saudi Arabia    | 29  | 425 | 14.66 |
| United Kingdom  | 26  | 433 | 16.65 |

communications technologies (ICTs): an increase from 1% of the global electricity consumption today up to 20% is projected by 2030 [70]. On the other hand, the critical nature of climate change is natural, and research on this topic has increased since 2012. Again, the focus on climate action and affordable energy may be related to the more technical nature of the publications in IEEE.

IV. LIMITATIONS OF THE STUDY

Our study has certain limitations. The citation analysis tool used in this study focuses only on the magnitude of the impact of the cited papers, and highly cited papers are not necessarily high-quality papers [76]. H-index is somewhat meaningless without a context within the author’s discipline, and it should be used with care to make comparisons because of its bias against early career researchers and those who started late or had career breaks. It also does not fully consider differences in disciplines. Dimensions is a new database, which has been improving significantly recently. Regarding coverage of data for journals, they source data from CrossRef and PubMed and then refine that through their direct agreement with publishers. For analyzing patterns in a journal, we do not see a problem in using the data from the Dimensions database. This is confirmed by the fact that we used some data from Scopus earlier, but now, even after getting data from Dimensions, those patterns observed remain largely the same. There have been several studies comparing the coverage of Dimensions database with Scopus and Web of Sciences [77][78] while highlighting its limitations also. It is possible to indirectly spam the dimensions database through preprint servers by uploading batches of non-peer-reviewed articles. There are also inconsistencies in the indexing of journal articles, such as
article types like “list of reviewers” or “editorial board”, which may inflate the number of articles in the dimensions database. In the case of Altmetrics, the Attention score does not necessarily indicate that the article is of high quality but indicates its popularity with the public, as seen in the social media platforms.

**V. CONCLUSION**

The article presents analytical results of publication and citation patterns, authorship structure, collaboration patterns, major funding sources, thematic structure, gender distribution, social-media visibility, and UN SDG connections of papers published in the IA journal. It is observed that in a very short period, IA has emerged as a preferred venue for the publication of research work in different areas of Engineering and Computer Science. The rapid and continuous publication of research work in different areas of Engineering and Computer Science has steadily increased over the years, reflecting the importance of these issues and the potential of novel technologies to tackle the challenges associated with them [66][68]. There is significant focus on SDGs 7 (on clean energy) and 13 (on climate action), which arguably constitute humanity’s most important challenges in the near future. The third-most-popular SDG in IA publications is SDG 3 (on health), due to the enormous potential of technology in this area and the numerous health-related challenges arising in today’s societies, for instance, in the context of the COVID-19 pandemic. Regarding IA publications on the pandemic, China, the US, and Australia lead in terms of the number of publications, while India exhibits a large number of citations per publication.

An area of future work would be comparing IA performance with similar open access journals, as open access is becoming a significant driver for publications.

Overall, it is seen that the IA journal has excellent potential when it comes to attracting novel, high-quality, multidisciplinary research. Given the focus areas connected to the SDGs, this journal is perfectly positioned to provide plausible solutions to these complex challenges. Two additional encouraging indicators of this journal are the increase of multi-authored interdisciplinary research and the percentage of articles with female first authors.

**REFERENCES**

[1] V. K. Singh, P. Singh, M. Karmakar, J. Leta, and P. Mayr, “The Journal Coverage of Web of Science, Scopus and Dimensions: A Comparative Analysis,” *Scientometrics* vol. 126, no. 6, pp. 5113–5142, Jun. 2021, doi: 10.1007/S11192-021-03948-5.

[2] L. Bornmann, “Field classification of publications in Dimensions,” *Scientometrics*, vol. 117, no. 1, pp. 637–640, Oct. 2018, doi: 10.1007/S11192-018-2855-Y.

[3] M. Thelwall, “Dimensions: A competitor to Scopus and the Web of Science?,” *J. Informetr.*, vol. 12, no. 2, pp. 430–435, May 2018, doi: 10.1016/J.JOLIOL2018.03.006.

[4] R. W. Moutardis, “Dimensions,” *J. Med. Libr. Assoc.*, vol. 107, no. 3, p. 459, Jul. 2019, doi: 10.5195/JMLA.2019.695.

[5] L. Bornmann and W. Marx, “Critical rationality and the search for standard (field-normalized) indicators in bibliometrics,” *J. Informetr.*, vol. 12, no. 3, pp. 598–604, Aug. 2018, doi: 10.1016/J.JOLIOL2018.05.002.

[6] C. Herzog, D. Hook, and S. Konkkel, “Dimensions: Bringing down barriers between scientometricians and data,” *Quant. Sci. Stud.*, vol. 1, no. 1, pp. 387–395, Feb. 2020, doi: 10.1162/QSS_A_00020.

[7] C. Chenid and M. Song, “Visualizing a field of research: A methodology of systematic scientometric reviews,” *PLoS One*, 2019, doi: 10.1371/journal.pone.0223994.

[8] D. W. Hook, S. J. Porter, H. Draux, and C. T. Herzog, “Real-Time Bibliometrics: Dimensions as a Resource for Analyzing Aspects of COVID-19,” *Front. Res. Metrics Anal.*, vol. 0, p. 25, Jan. 2021, doi: 10.3389/FRMA.2020.595299.

[9] V. K. Singh, A. Uddin, and D. Pinto, “Computer science research: the top 100 institutions in India and in the world,” *Scientometrics*, vol. 104, no. 2, pp. 529–553, Aug. 2015, doi: 10.1007/S11192-015-1612-8.

[10] V. Garoussi and M. V. Mäntylä, “Citations, research topics and active countries in software engineering: A bibliometric study,” *Comput. Sci. Rev.*, vol. 19, pp. 56–77, Feb. 2016, doi: 10.1016/J.COSREV.2015.12.002.

[11] V. K. Singh, S. K. Banshal, K. Singhal, and A. Uddin, “Scientometric mapping of research on ‘Big Data,’” *Scientometrics*, vol. 105, no. 2, pp. 727–741, Nov. 2015, doi: 10.1007/S11192-015-1729-9.

[12] B. N. Yan, T. S. Lee, and T. P. Lee, “Mapping the intellectual structure of the Internet of Things (IoT) field (2000–2014): a co-word analysis,” *Scientometrics*, vol. 105, no. 2, pp. 1285–1300, Nov. 2015, doi: 10.1007/S11192-015-1740-1.

[13] K. Y. Tang, C. Y. Chang, and G. J. Hwang, “Trends in artificial intelligence-supported e-learning: a systematic review and citation network analysis (1998–2019),” *Interact. Learn. Environ.*, 2021, doi: 10.1080/10494820.2021.1875001.

[14] M. J. Cobo, A. G. López-Herrera, E. Herrera-Viedma, and F. Herrera, “An approach for detecting, quantifying, and visualizing the evolution of a research field: A practical application to the Fuzzy Sets Theory field,” *J. Informetr.*, vol. 5, no. 1, pp. 146–166, Jan. 2011, doi: 10.1016/J.JOLIOL2010.10.002.

[15] P. Waila, V. K. Singh, and M. K. Singh, “A Scientometric Analysis of Research in Recommender Systems,” *J. Scientometr. Res.*, vol. 5, pp. 71–84, May 2016, doi: 10.5530/jicsres.5.1.10.

[16] S. K. Banshal, V. K. Singh, A. Basu, and P. K. Muhuri, “Research performance of Indian Institutes of Technology,” *Curr. Sci.*, vol. 112, no. 5, pp. 923–932, 2017, doi: 10.18520/cs/v112/05/923-932.

[17] A. Basu, S. K. Banshal, K. Singhal, and V. K. Singh, “Designing a Composite Index for research performance evaluation at the national or regional level: ranking Central Universities in India,”
This article has been accepted for publication in a future issue of this journal, but has not been fully edited. Content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2022.3161639, IEEE Access

[56] J. Ma, “The Most Popular Papers Published in 2019,” IEEE Trans. Microw. Theory Tech., vol. 69, no. 2, pp. 1177–1179, Feb. 2021, doi: 10.1109/TMFF.2021.3050574.

[57] P. Singh, R. Piryani, V. K. Singh, and D. Pinto, “Revisiting subject classification in academic databases: A comparison of the classification accuracy of Web of Science, Scopus Dimensions,” J. Intell. Fuzzy Syst., vol. 39, no. 2, pp. 2471–2476, 2020, doi: 10.3233/JIFS-179906.

[58] D. Zhang et al., “2021 AI Index Report,” pp. 1–222, 2021, [Online]. Available: https://aindex.stanford.edu/report/.

[59] C. Warten, R. Brussee, and W. Slakhorst, “Keyword extraction using word co-occurrence,” Proc. - 21st Int. Work. Database Expert Syst. Appl. DEXA 2010, pp. 54–58, 2010, doi: 10.1109/DEXA.2010.32.

[60] S. A. Azor and S. Azer, “Top-cited articles in medical professionalism: a bibliometric analysis versus altmetric scores,” BMJ Open, vol. 9, no. 7, pp. e029433, Jul. 2019, doi: 10.1136/bmjopen-2019-029433.

[61] L. Bornmann and R. Haunschild, “Do altmetrics correlate with the quality of papers? A large-scale empirical study based on F1000Prime data,” PLoS One, vol. 13, no. 5, May 2018, doi: 10.1371/journal.pone.0197133.

[62] M. Thelwall, S. Haustein, V. Larivière, and C. R. Sugimoto, “Do Altmetrics Work? Twitter and Ten Other Social Web Services,” PLoS ONE, vol. 8, no. 5, May 2013, doi: 10.1371/journal.pone.0064841.

[63] R. Costas, Z. Zahedi, and P. Wouters, “Do ‘altmetrics’ correlate with citations? Extensive comparison of altmetric indicators from a multidisciplinary perspective,” Journal of the Association for Information Science and Technology, vol. 66, no. 10, pp. 2003–2019, Jul. 2014, doi: 10.1002/asi.23309.

[64] C. S. Armitage, M. Lorenz, and S. Mikki, “Mapping scholarly publications related to the Sustainable Development Goals: Do independent bibliometric approaches get the same results?,” Quant. Sci. Stud. vol. 1, no. 3, pp. 1092–1108, Aug. 2020, doi: 10.1162/QSS_A_00077.

[65] C. Meschede, “The sustainable development goals in scientific literature: A bibliometric overview at the meta-level,” Sustain., vol. 12, no. 11, Jun. 2020, doi: 10.3390/SU12114461.

[66] R. Vinuesa et al., “The role of artificial intelligence in achieving the Sustainable Development Goals,” Nat. Commun., vol. 11, no. 1, pp. 1–10, Dec. 2020, doi: 10.1038/S41467-019-14108-Y.

[67] S. Gupta et al., “Assessing whether artificial intelligence is an enabler or an inhibitor of sustainability at indicator level,” Transp. Eng., vol. 4, Jun. 2021, doi: 10.1016/j.TRENG.2021.100064.

[68] J. Wu, S. Guo, H. Huang, W. Liu, and Y. Xiang, “Information and communications technologies for sustainable development goals: State-of-the-art, needs and perspectives,” IEEE Commun. Surv. Tutorials, vol. 20, no. 3, pp. 2389–2406, Jul. 2018, doi: 10.1109/COMST.2018.2812301.

[69] A. Kamama, E. B. Haghhigh, and R. Vinuesa, “Organic data centers: A sustainable solution for computing facilities,” Results Eng., vol. 4, Dec. 2019, doi: 10.1016/J.RINENG.2019.100063.

[70] N. Jones, “How to stop data centres from gobbling up the world’s electricity,” Nature, vol. 561, no. 7722, p. 167, Sep. 2018, doi: 10.1038/D41586-018-06610-Y.

[71] M. El Mohadab, B. Bouikhalene, and S. Safi, “Bibliometric method for mapping the state of the art of scientific production in Covid-19,” Chaos, Solitons and Fractals, vol. 139, Oct. 2020, doi: 10.1016/J.CHAOS.2020.110052.

[72] R. Raman, K. Achuthan, R. Vinuesa, and P. Nedungadi, “Covid19 covid-19 tracing app scale—an evaluation framework,” Sustain., vol. 13, no. 5, Mar. 2021, doi: 10.3390/SU13052912.

[73] R. Raman, R. Vinuesa, and P. Nedungadi, “Bibliometric analysis of SARS, MERS, and COVID-19 studies from India and connection to sustainable development goals,” Sustain., vol. 13, no. 14, Jul. 2021, doi: 10.3390/SU13147555.

[74] R. Raman, B. Sairam, G. Veena, H. Vachharajani, and P. Nedungadi, “Adoption of online proctored examinations by university students during COVID-19: Innovation diffusion study,” Educ. Inf. Technol., vol. 26, no. 6, pp. 1–20, Nov. 2021, doi: 10.1007/S10639-021-10581-5/FIGURES/6.

[75] R. Raman, R. Vinuesa, and P. Nedungadi, “Acquisition and user behavior in online science laboratories before and during the COVID-19 pandemic,” Multimodal Technologies and Interaction, vol. 5, no. 8, p. 46, Aug. 2021, doi: 10.3390/mti5080046.

[76] D. F. Thompson and C. K. Walker, “A Descriptive and Historical Review of Bibliometrics with Applications to Medical Sciences,” Pharmacotherapy: The Journal of Human Pharmacology and Drug Therapy, vol. 35, no. 6, pp. 551–559, May 2015, doi: 10.1002/phar.1586.

[77] A. Martín-Martín, M. Thelwall, E. Orduna-Malea, and E. D. López-Cózar, “Correction to: Google Scholar, Microsoft Academic, Scopus, Dimensions, Web of Science, and OpenCitations’ COCI: a multidisciplinary comparison of coverage via citations,” Scientometrics, vol. 126, no. 1, pp. 907–908, Dec. 2020, doi: 10.1007/s11192-020-03792-z.

[78] M. Thelwall, “Dimensions: A competitor to Scopus and the Web of Science?,” Journal of Informetrics, vol. 12, no. 2, pp. 430–435, May 2018, doi: 10.1016/j.joi.2018.03.006.

RAGHU RAMAN, Ph.D., is the Dean of School of Business at Amrita Vishwa Vidyapeetham. He holds a Ph.D. degree in Management from Amrita Vishwa Vidyapeetham, India and an MBA from Haas School of Business, UC Berkeley, USA. He has over 30 years of executive management experience at variety of fortune 500 companies and has been with Amrita Vishwa Vidyapeetham since its founding in 2003. With main research focus in the areas of Adaptive learning environments, Diffusion of ICT Innovations in Socio-technical systems, studies of world-class universities, prediction models for rankings, Internationalization of higher education etc., he established the Center for Research in Analytics & Technologies for Education (CREATE), with over $5mn in research funding and has 60+ peer reviewed publications. As an Entrepreneur-in-Residence at NEC Research Labs, he raised over $16.5m in VC funding for an Intelligent Video surveillance start-up. Prof. Raman is recipient of President of India gold medal in 1986. He serves on the board of director for Amrita Technology Business Incubator and is the past chair of IEEE Education Society Chapter, India.

PRASHASTI SINGH received M.Sc. (Computer Science) degree from the Department of Computer Science, Institute of Science, Banaras Hindu University in 2017. She is currently a Doctoral Research Scholar at the Department of Computer Science, Institute of Science, Banaras Hindu University since 2018. Her research interests include Scientometrics, coverage and retrieval in Scholarly Databases, country-specific Scientometric studies and Data Analytics.
VIVEK KUMAR SINGH, D.Phil., is Professor and Head of the Department of Computer Science at Banaras Hindu University, Varanasi, India. He has received Bachelor's, Master's and Doctoral Degrees, all in Computer Science, from University of Allahabad, Allahabad, India. His research interests are in Information Systems, Scientometrics, Text Analytics and Artificial Intelligence. His research is funded by Department of Science and Technology (DST), Govt of India, Science and Engineering Research Board (SERB), India and Ministry of Electronics & Information Technology (MeitY), Govt of India. He is a senior member of IEEE and member of ACM, ISSI, IETE and CSI.

RICARDO VINUESA is an Associate Professor at the Department of Engineering Mechanics, at KTH Royal Institute of Technology in Stockholm. He is also a Researcher at the AI Sustainability Center in Stockholm and Vice Director of the KTH Digitalization Platform. He received his Ph.D. in Mechanical and Aerospace Engineering from the Illinois Institute of Technology in Chicago. His research combines numerical simulations and data-driven methods to understand and model complex wall-bounded turbulent flows, such as the boundary layers developing around wings, obstacles, or the flow through ducted geometries. Dr. Vinuesa’s research is funded by the Swedish Research Council (VR) and the Swedish e-Science Research Centre (SeRC). He has also received the Göran Gustafsson Award for Young Researchers.

PREMA NEDUNGADI is the Chairperson of the Department of Computer Science, Amritapuri, Amrita Vishwa Vidyapeetham. She received her Ph.D. in CSE from Amrita Vishwa Vidyapeetham. Her interest is in interdisciplinary projects that combine AI, Reading Difficulties, Human-Computer Interface, Computational Linguistics to build scalable systems. Her research is funded by the Ministry of Electronics and Information Technology, Ministry of Science & Technology, Ministry of Tribal Affairs, and Ministry of Education. She received the Digital India Award from the Ministry of Electronics and Information Technology, in the category Digital Empowerment, and was a finalist in the $7 million US-based Barbara Bush Foundation Adult Literacy XPRIZE competition.