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Bibliometric Survey on Reconfigurable Antenna for MIMO systems

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ABSTRACT

The aim of this study is to analyse the work done on the frequency and polarization reconfigurability of antenna for various design types using the bibliometric study methods. Different articles on reconfigurable antennas for MIMO systems were retrieved using SCOPUS which is one of the most popular databases. The research articles published between 2004 to 2020 were considered and Scopus Analyser was used to fetch the analysis results namely document by source, author, subject, year and country. In the currently available literature, a lot of survey articles on the reconfigurable antennas and MIMO systems is available but there is no bibliometric analysis conducted till date. Hence, this in this article, the bibliometric study with an emphasis on the reconfigurable antennas and their applications in the MIMO systems is undertaken. The aim of this article is to explore the present research conducted referring to the articles published each year, keywords used over time, topmost keywords used each year, journals publishing most papers over time and each year as well. The data that is articulated will support the basic understanding of the topic and emphasize the fact that there is an enormous opportunity for the research clusters to explore the field of reconfigurable antennas.

Keywords: Reconfigurable antenna, MIMO systems, survey, wireless systems, RF current, polarisation, frequency, Scopus, Bibliometric.

1. Introduction

Reconfigurable antenna is the type of antenna which has an ability to dynamically modify its radiation and frequency properties in a precise and reversible method [6]. To achieve this dynamic response, the reconfigurable antennas integrate the varactor diodes, actuators and RF switches to facilitate the deliberate redistribution of the RF currents over the surface of the antenna in order to produce reversible alterations to the properties. The differentiating factor of the reconfigurable antenna compared to the smart antenna is that the mechanism of the reconfiguration lies in the internal part rather than in the external

network. In order to satisfy the ever-changing scenarios and operating requirements, the reconfiguration ability of the reconfigurable antennas is used. Reconfigurability with respect to polarisation is an important aspect in case of MIMO systems as they require multiple inputs in order to reduce fading. The typical antennas pose a limit to the level of intelligence that can be introduced to the MIMO systems as their characteristics are fixed for certain functionalities [1,2]. Subsequently, the realisation of MIMO antennas is an emerging area in the wireless domain with solutions that offer compliance to the ever-changing requirements of the wireless environment [3,4].

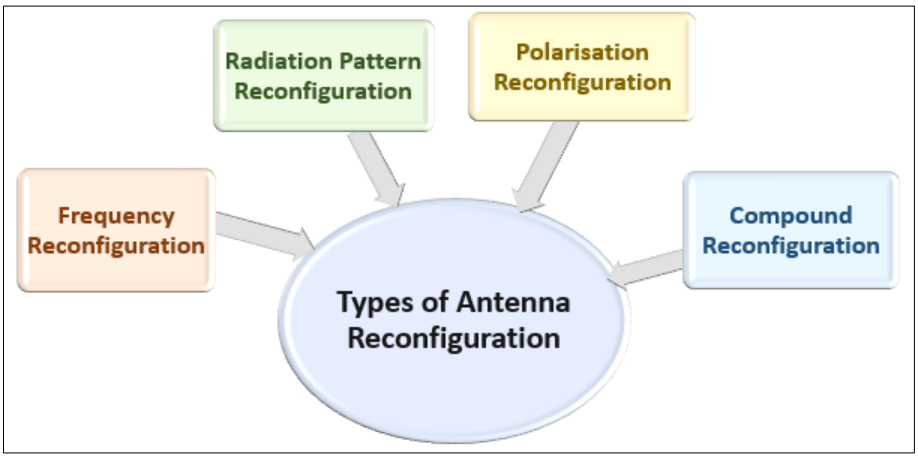


Fig. 1: Types of Antenna Reconfiguration

The reconfigurable antennas can be distinguished on the basis of the antenna parameters like polarisation, frequency of operation or pattern of the radiation and can be adjusted dynamically. Fig. 1 shows the types of the antenna reconfiguration viz.- frequency reconfiguration, radiation pattern reconfiguration, compound reconfiguration and polarisation reconfiguration. Operating frequency can be varied dynamically in case of frequency reconfiguration which is achieved by making electrical and physical alterations to the dimensions of the antenna. Calculated alterations are made on the spherical distribution in the radiation pattern reconfiguration in order to maximize the gain of the antenna. Switching between vertical, horizontal and circular polarization in order to reduce the mismatch loss is achieved using polarisation reconfiguration antennas and ability to simultaneously tune various antenna parameters is achieved using compound reconfiguration antenna [1-15].

2. Preliminary Data Collection

This article is framed by sending a query to the SCOPUS database using main keywords like Reconfigurable antennas AND MIMO systems as shown in Table 1.

Table 1 Query sent to the SCOPUS database

Primary Keywords	"Reconfigurable Antenna"
Secondary Keywords	"MIMO systems" AND "Compact Antenna" AND "Polarisation" AND "Radiation Pattern"

(Source: Scopus DB accessed on 31st December 2020)

Using the aforementioned query string, we retrieved 221 publications from the Scopus database which were in English, 5 in Chinese and 1 in Russian language. Table 2 shown below indicates the publication count for each language.

Table 2 Details of the Language used for Publication

Language of Publication	Total Count
English	221
Chinese	5
Russian	1

(Source: Scopus DB accessed on 31st December 2020)

3. Bibliometric Information and Performance Analysis

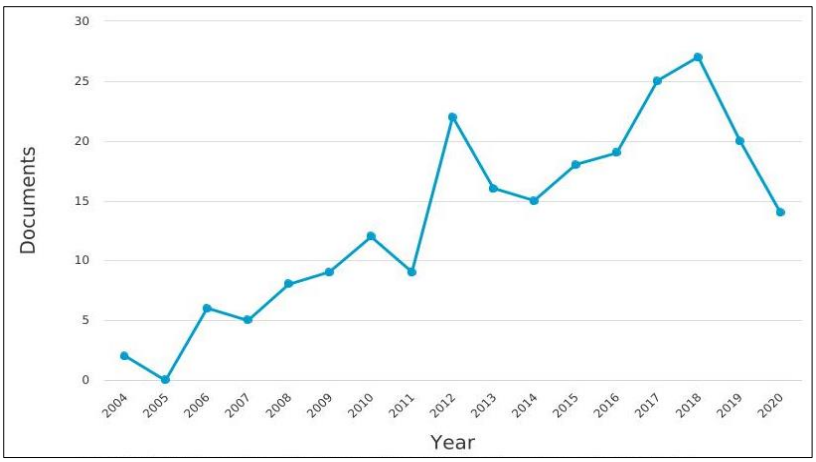
The information regarding the query posted on the Scopus database is obtained in the *.csv* file format. The information that is retrieved for the same is expressed using the following details used for further analysis –

1) The statistical analysis of the databases is done considering the documents by – prominent authors, source, year, subject area, type, contributing country, key affiliations and funding sponsors.
2) Another important aspect to be highlighted is the representation of the data fetched from the Scopus database in the form of network diagrams and graphs. The information used for the same is based on the co-authorship (authors, organisations, country), co-occurrence (all keywords, author keywords, index keywords), citation analysis (source, author, organisations, country) and bibliographic coupling (documents, authors).

4. Results and Discussion

4.1 Preliminary Data Analysis

Fig. 2 shows the count of the publication from 2004 to 2020.There is a significant increase in the publications from the year 2010 to 2020 which was not observed from 2004 to 2009. This implies that there is a significant surge in this research area till 2018.



Year	Number of Publications
2020	14
2019	20
2018	27
2017	25
2016	19
2015	18
2014	15
2013	16
2012	22
2011	9
2010	12

Fig. 2: Yearwise Publication Count
(Source: Scopus DB accessed on 31st December 2020)

Fig. 3 shows the eminent authors with a significant contribution in this research area. The first author has maximum number of Scopus documents (25) on his name where as other second, third and fourth authors have more than 10 documents. The remaining ones have documents varying from 5 to 10 on their name. This clearly points to the scope of this research area and the contribution of the authors towards the same.

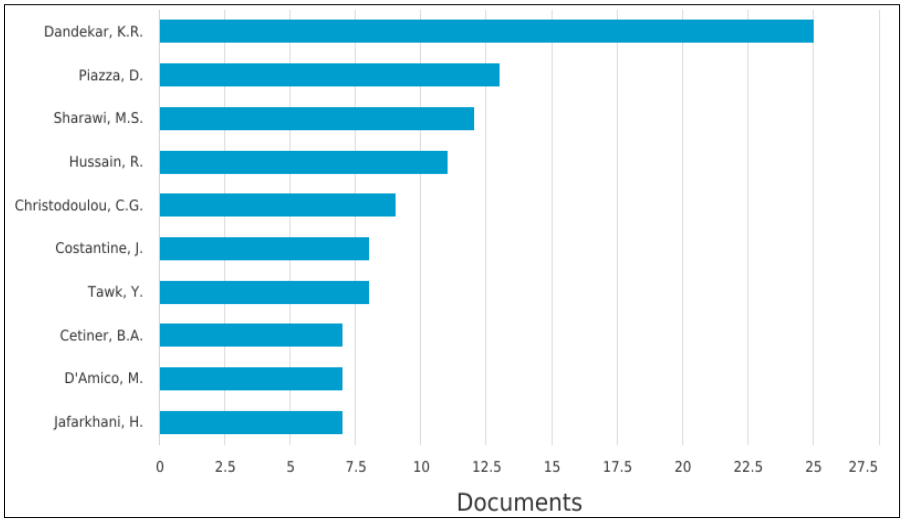


Fig. 3: Prominent Authors (Source: Scopus DB accessed on 31st December 2020)

From the Fig. 4 it is observed that the most popular source titles were *IEEE Transactions On Antennas And Propagation, IEEE Antennas And Wireless Propagation Letters, IEEE Antennas And Propagation Society AP S International Symposium Digest and Microwave And Optical Technology Letters*. While *IEEE Transactions On Wireless Communications* and *IEEE Access* also had significant number of documents.

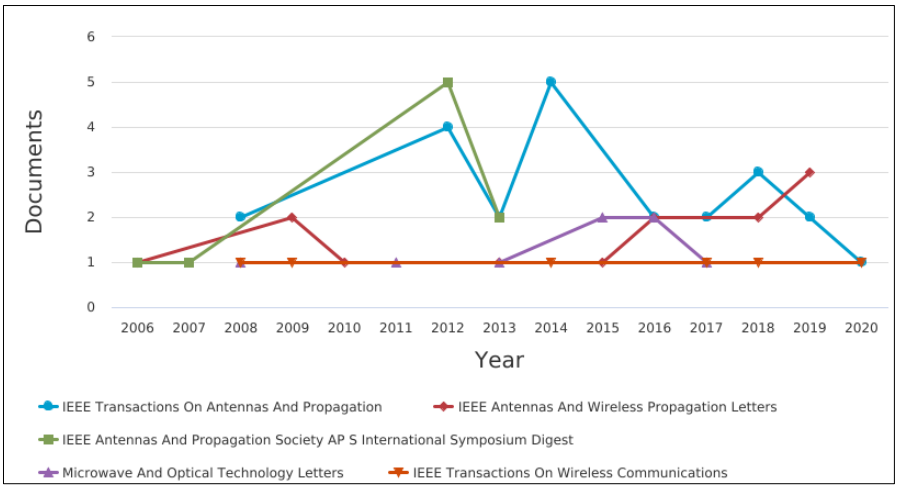


Fig. 4: Documents per year by Source.
(Source: Scopus DB accessed on 31st December 2020)

Referring to Fig. 5, it can be observed that the maximum number of publications are from - Drexel University, King Fahd University of Petroleum and Minerals and University of California, Irvine whereas Fig. 6 indicates that maximum number i.e., 76 publications are from the USA followed by China, Canada and Germany.

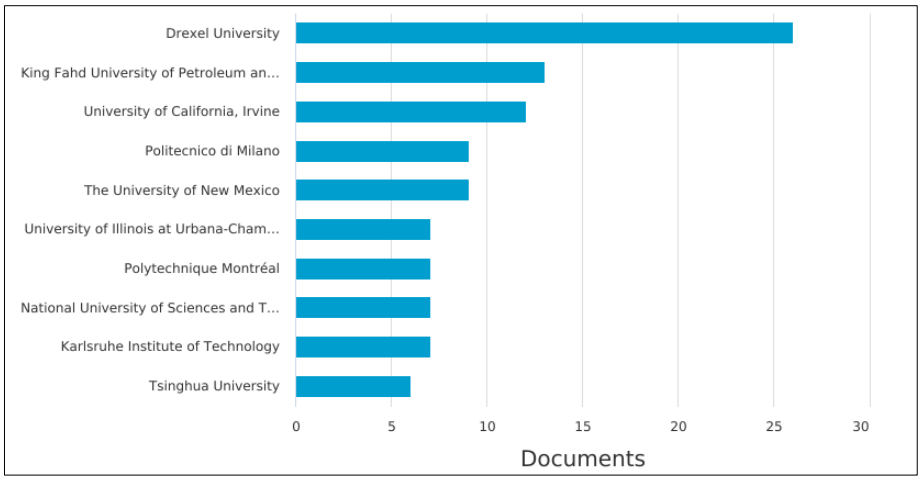
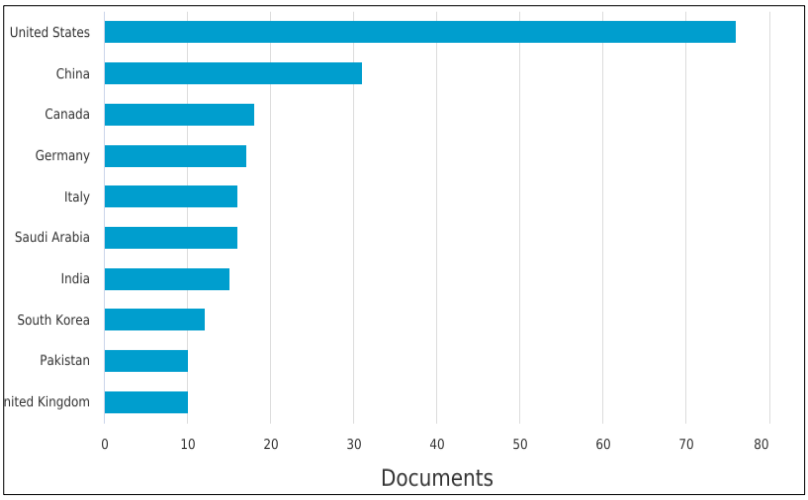


Fig. 5: Documents by Affiliation.
(Source: Scopus DB accessed on 31st December 2020)



Country / Territory	Publications
United States	76
China	31
Canada	18
Germany	17
Italy	16
Saudi Arabia	16
India	15
South Korea	12
Pakistan	10
United Kingdom	10

Fig. 6: Documents by Country or Territory.
(Source: Scopus DB accessed on 31st December 2020)

Fig. 7 indicates maximum number i.e. 113 conference papers and 104 articles are published followed by 4 conference review, 3 book chapters and 2 reviews. Apparently, the count of the editorial and the review is less which has significant scope for improvement.

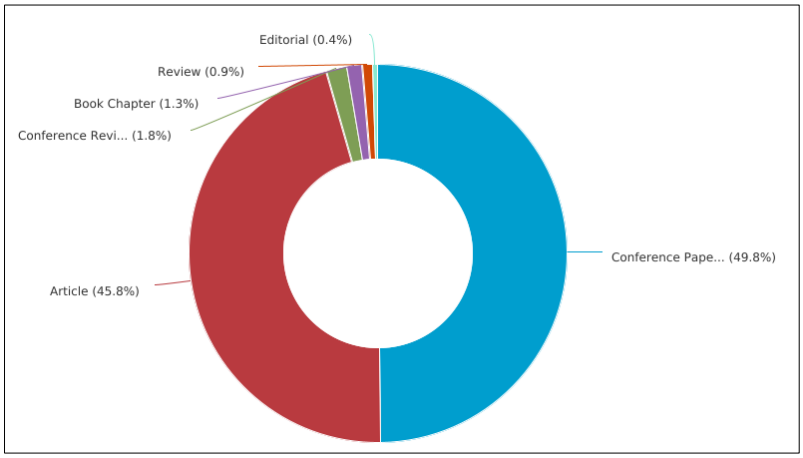
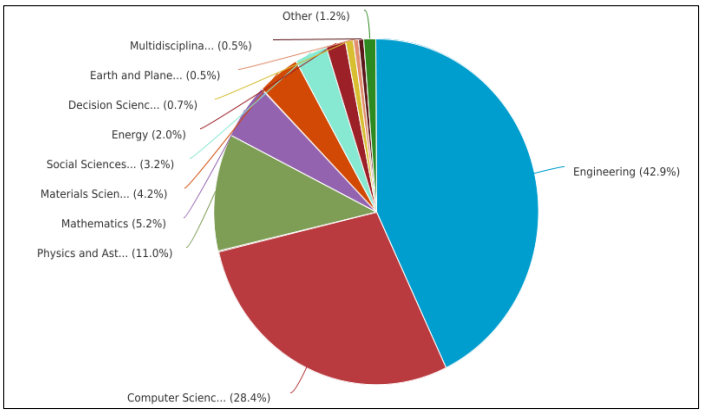


Fig. 7: Documents by Type. (Source: Scopus DB accessed on 31st December 2020)

Fig. 8 indicates that Engineering and Computer Science are the top contributing areas with 172 and 114 documents respectively followed by Physics, Astronomy, Mathematics, Material Science and Social Sciences. Energy being on the lowest research groups.



Subject Area	Publication
Engineering	172
Computer Science	114
Physics and Astronomy	44
Mathematics	21
Materials Science	17
Social Sciences	13
Energy	8

Fig. 8: Documents by Subject Area
(Source: Scopus DB accessed on 31st December 2020)

Fig. 9 indicates that the main funding agencies that has sponsored the research work is National Science Foundation followed by National Natural Science Foundation of China, King Fahd University of Petroleum and Minerals and Air Force Office of Scientific Research

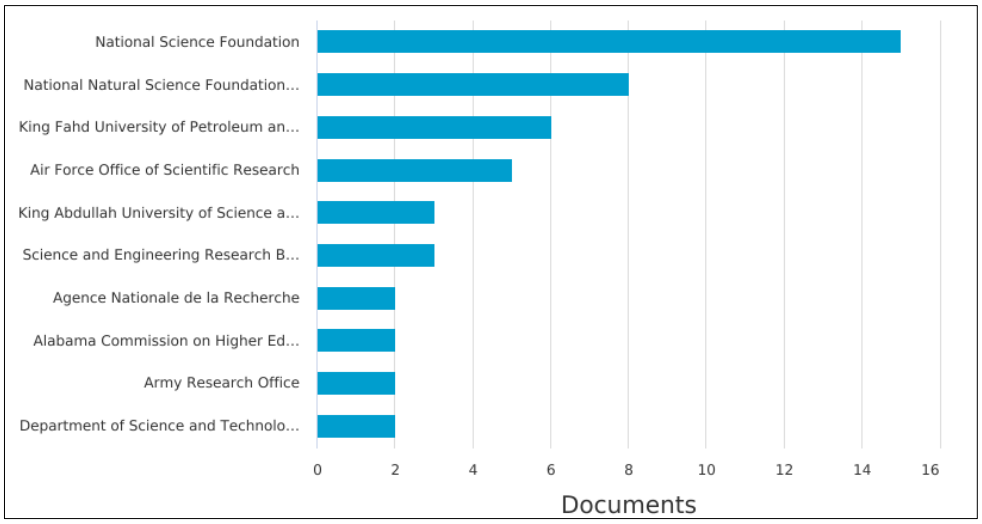


Fig. 9: Documents by Funding Sponsor.
(Source: Scopus DB accessed on 31st December 2020)

Fig. 10 clearly indicates that the CiteScore publication by *IEEE Transactions on Wireless Communications* is the maximum followed by *IEEE Transactions on Communications* and *IEEE Transactions on Antenna and Propagations.*

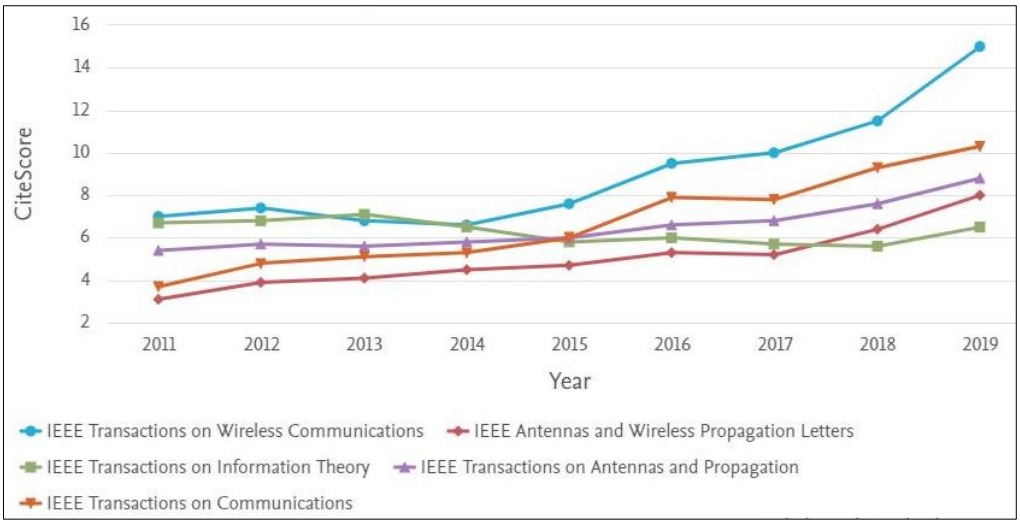


Fig. 10: CiteScore publication by year
. (Source: Scopus DB accessed on 31st December 2020)

4.2 Bibliometric Analysis through Networked Diagrams

All the network diagrams mentioned from Fig. 11 to Fig. 20 are drawn and enhanced using tools which are available on https://medialab.github.io/sciencescape/ link and https://medialab.sciencespo.fr/en/tools/minivan/ link.

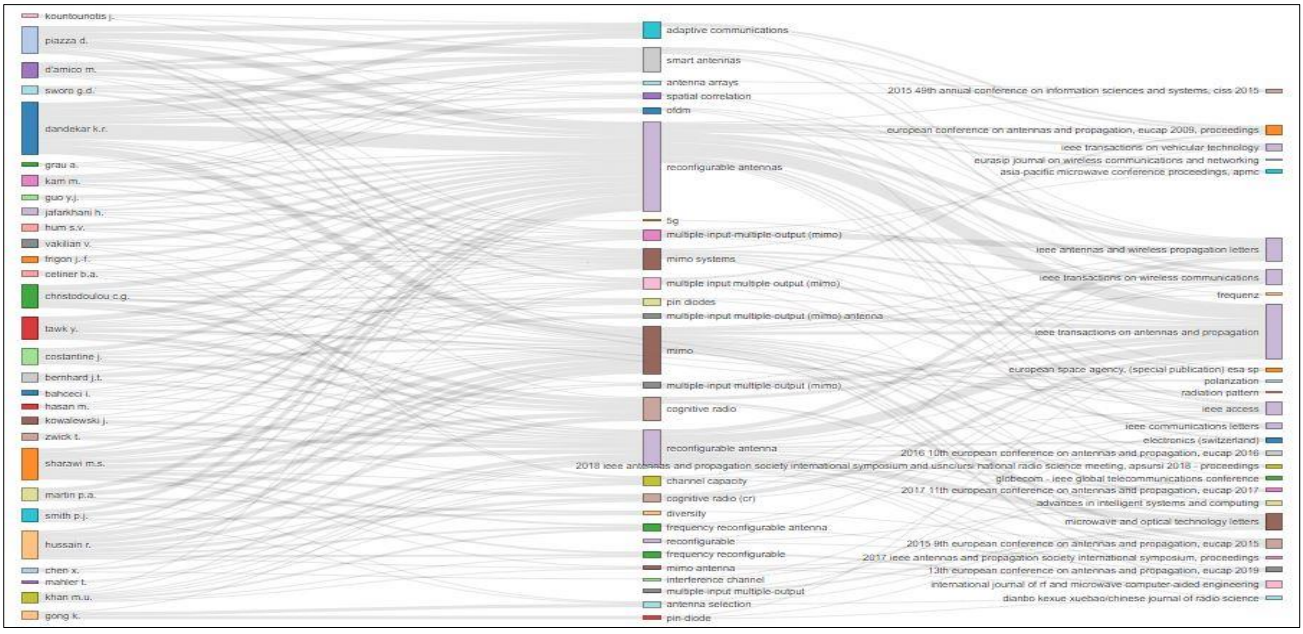


Fig. 11: Graph: Authors-Keywords-Journal (Sankey Diagram)
(Source: Scopus DB accessed on 31st December 2020)

The graph shown above in Fig. 11 reflects the relation between authors, keywords and journal and is represented using a Sankey Diagram which is also represented in a tabulated form in Fig. 12.

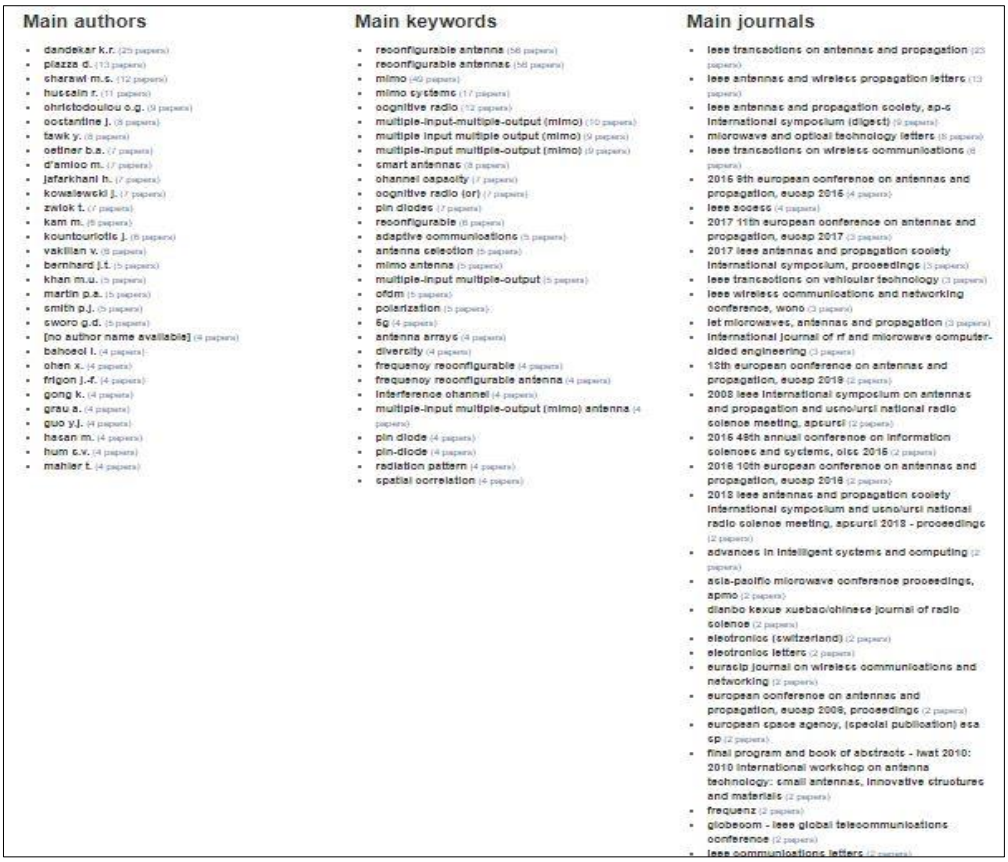


Fig. 12: Tabular Information: Authors-Keywords-Journal (Sankey Diagram)
(Source: Scopus DB accessed on 31st December 2020)

The A-K-J Sankey helped us to visualize the main authors, keywords and journals and their relation with each other.

Fig. 13: Journals over time: 2010 to 2015
(Source: Scopus DB accessed on 31st December 2020)

The journals published over time period 2010 to 2015 are mentioned in Fig. 13 and the journals published over the time period 2016 to the year 2020 are shown in Fig. 14.

Fig. 14: Journals over time: 2016 to 2020
(Source: Scopus DB accessed on 31st December 2020)

The top trending keywords published in the documents from the year 2012 to 2019 is shown in the Fig. 15 in a tabular format.

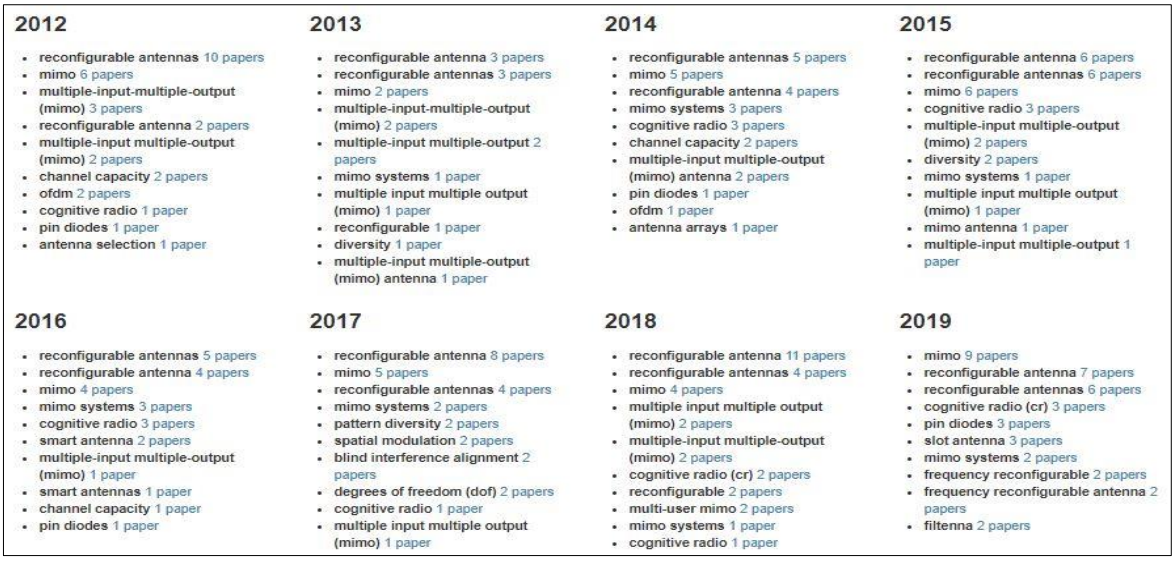


Fig. 15: Top Keywords: 2012 to 2019
(Source: Scopus DB accessed on 31st December 2020)

Several keywords are used for the analysis of the co-occurrences. The most prominent keywords out of all the available ones are – *backscatter communication, reconfigurable antenna, multiple input multiple output*. The correlated authors are – *Ali w.a.e , Christodoulou c.g, Tawk y*. etc. Authors and keywords co-appearing in the same papers are shown by the network diagram in Fig. 16 as below.

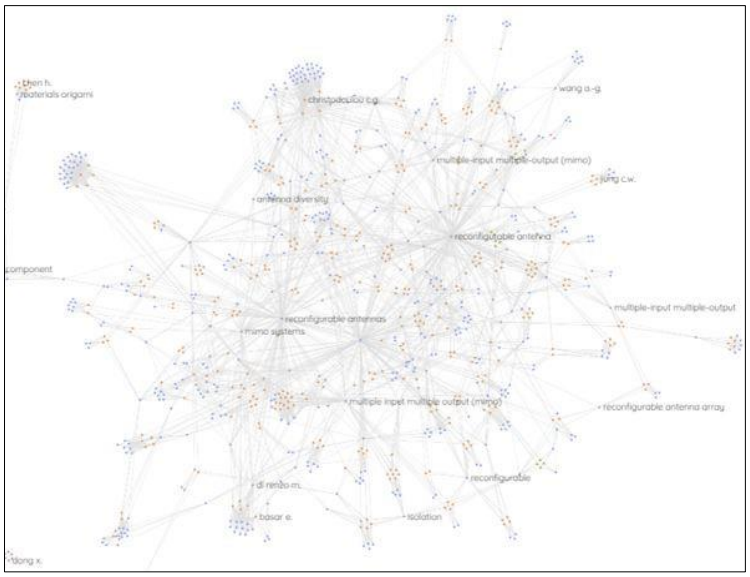


Fig. 16: Authors and Author Keywords co-appearing in the same papers
(Source: Scopus DB accessed on 31st December 2020)

Fig. 17 as shown below depicts the author keywords co-appearing in the same papers. Important keywords to be highlighted are – *cognitive radio (cr), dual polarization, WLAN, Adaptive MIMO, pin diodes, etc.*

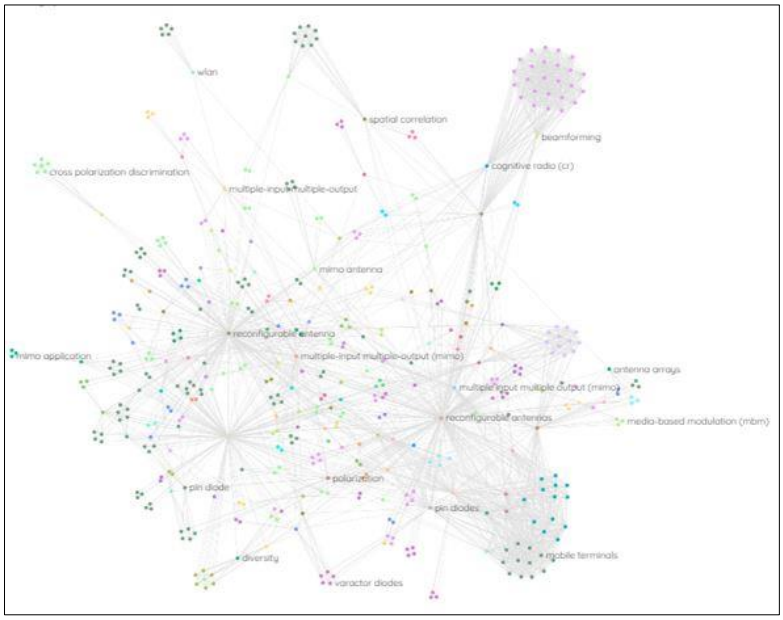


Fig. 17: Authors Keywords co-appearing in the same papers
(Source: Scopus DB accessed on 31st December 2020)

Authors and source titles co-appearing in the same papers is highlighted in Fig. 18 as shown below. Renowned authors like *Dandekar KR, Vakilian V, Damico M* e.tc are mentioned along with the source titles linked to them such as *IEEE Transactions on Antenna and Propagation, 2017 11th Conference on Antennas and Propagation, Eurasip Journal on Wireless Communication and Networking*.

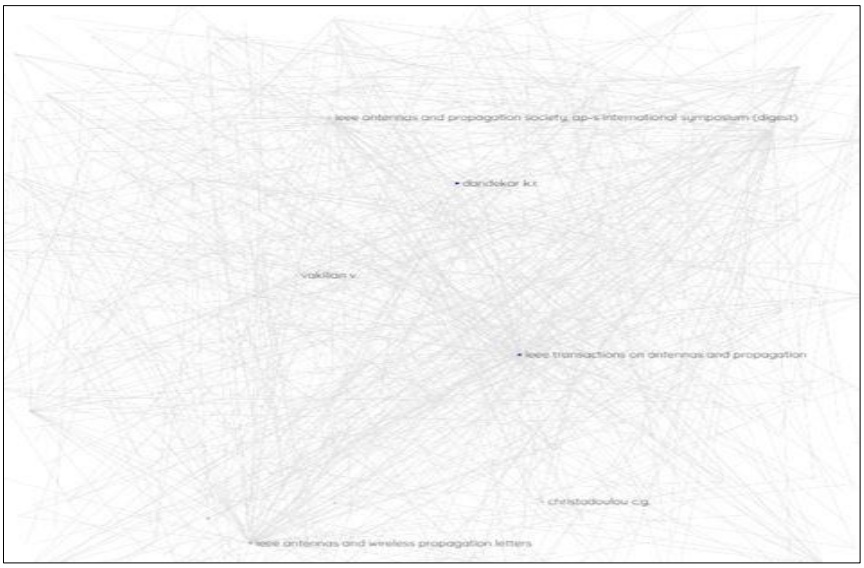


Fig. 18: Authors and Source Titles co-appearing in the same papers
(Source: Scopus DB accessed on 31st December 2020)

Several authors are linked by co-publication as shown in Fig. 19. For instance, authors like – *Dandekar K R, D'Amico M, Piazza D, Kirsch NJ, Sworo G D, Gulati N* etc are linked to each other by co-publication and is depicted really well in the form of connected nodes in the Fig. shown below.

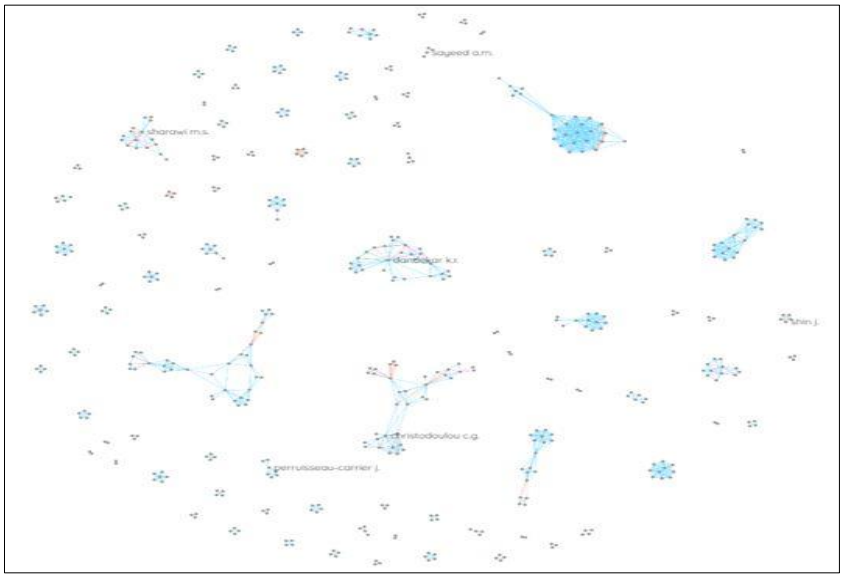


Fig. 19: Authors Linked by Co-Publication
(Source: Scopus DB accessed on 31st December 2020)

Fig. 20 shows a simple node diagram of the papers linked with citations when they have DOI data available. Example of the papers linked as shown in the diagram is – *Impact of pattern reconfigurable antennas on interference alignment over measured channels* and *Design and evaluation of reconfigurable antenna array for MIMO systems.*

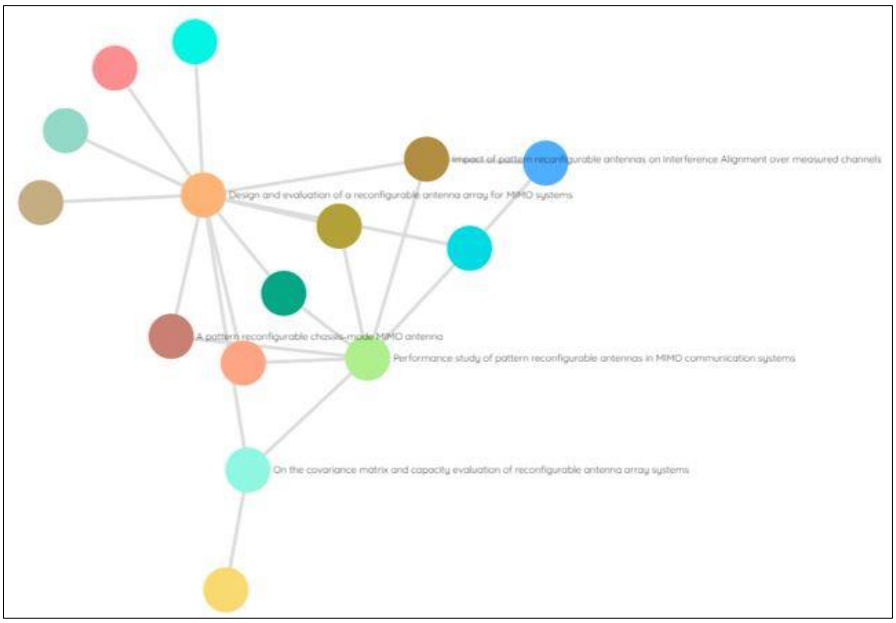


Fig. 20: Papers Linked by Citation (when they have DOI) [35]
(Source: Scopus DB accessed on 31st December 2020)

Source title and author keywords co-appearing in the same paper is depicted in Fig. 21. For example, the titles such as *Microwave and Optic Technology Letters* and *IEEE transactions on Wireless Communication* is a classic example of co-appearing source titles with the connecting author keywords like – *antenna arrays, adaptive and reconfigurable antennas, frequency, diversity* etc.

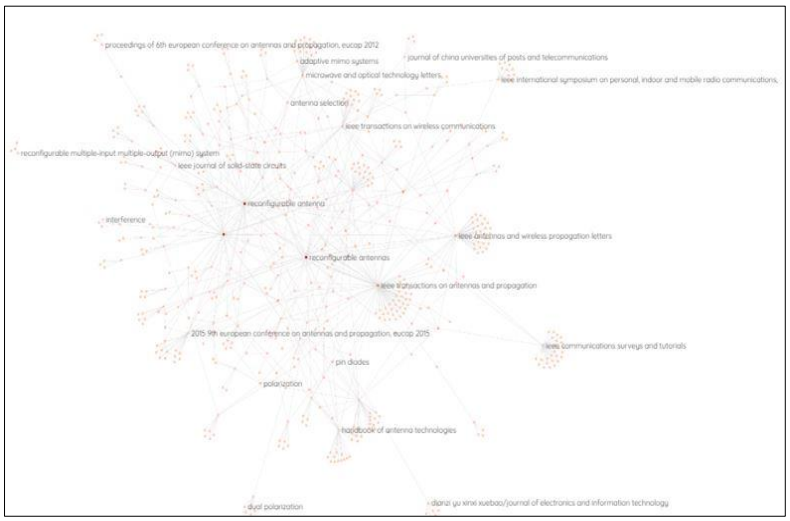


Fig. 21: Source Title and Author Keywords coappearing in the same papers [36]
(Source: Scopus DB accessed on 31st December 2020)

5 Research Implications

Although there are considerable number of research articles available on the given topic, only a few articles or documents are from Indian Universities and by Indian authors. Since India is a developing country and with a lot of potential and talent, there is a lot of scope for a good quality research and publication output. There is an immense scope for the new authors to showcase their work and the count of documents released in the last decade supports the point really well. The articulation of this novel bibliometric review paper on the given research topic will highlight the information about points and keywords which were less focus earlier and also throw some light on the information like – keywords, co-appearance with respect to authors and author keywords, source titles etc. beneficial to the new researchers.

6 Conclusion

In this article, a thorough and comprehensive bibliometric study and analysis is undertaken. The main area of focus was the Reconfigurable antenna with respect to the MIMO systems. All the essential information was extracted from the search engine based on the esteemed Scopus database. With the help and use of the information retrieved from the Scopus database the idea of identifying and relating the authors with the topic to be studied, the journals, the keywords and other information was easily conceivable. Approximately 45% of the work is related to the field of Engineering and 28% to that of Computer Science. Most of the documents that were published in SCOPUS were either the conference papers or the journal articles. The SCOPUS database has suggested close to 227 articles on the topic related to Reconfigurable antennas for MIMO systems which is an excellent opportunity for the new researchers to start their research from and get the necessary literature readily available.

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