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Bibliometric Review of Boot-Loading Microcontroller Through Serial Port

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ABSTRACT

Modern-day automobiles have several Electronic Control Units (ECUs) integrated into them so naturally, compared to the older cars, their complexity is too high, and this trend of increasing complexity in the cars of the future will continue to increase. Consequently, with the increase in the software part in the vehicles, there is always the risk of a potential bug. Whenever a software bug is found, a recall process is required to update the software. The modern ECU update technology is achieved through the interaction of information between the remote server and the end equipment of the vehicle. Therefore, due to the development of the network technology, the ECU remote upgrade technology has the application environment and the technology base. The primary purpose of this bibliometric analysis is to recognize the horizon of literature obtainable in the field of microcontroller boot loading procedures through serial ports. This bibliometric review is mainly based on the database of Scopus, IEEE, NXP community and software like Microsoft Excel and GPS visualizer. From this bibliometric review it is observed that prime publications come from conference, articles and journals from Chinese publishers, followed by US and Indian publishers and some from South Korea. The research articles published between the years 2011 to 2021 were considered. Most of the contributions came from disciplines such as Computer Technology and Engineering, followed by Mathematics.

Keywords: Boot Loaders, Bootloader, Firmware, Firmware updates, Embedded systems and Application Programs.

1. INTRODUCTION

In recent years, rapid growth in the amount of software used in automobiles has been reported. Complicated software is difficult to maintain, especially due to the constant changes which are important in the automobile evolution process. To stay clear of the potential unwanted impact of changes on the system quality attributes, appropriate measurements of the above-mentioned changes are needed. Studies have shown that more than 80% of innovations in automobiles are related to software, and most innovations are increasing the interaction between parts of the system that were previously less dependent. At the same time, the quality standards of safety, reliability and performance including the software must be maintained at a high level. Most quality attributes can be improved with the utilization of the software. Also, updates are done by using the a/b swap technique but they are limited only to the microcontrollers with high-density memory, such as the gateway or infotainment unit.

Another concern is to keep the update process secure to protect the update against possible eavesdropping, replication attacks etc. Traditional upgrade technology is so complicated that only professionals can perform it. This is time-consuming and expensive as they have to disconnect the ECU from the vehicle, use a dedicated downloader and interface to update the program in the ECU. Therefore, wireless remote update technology is of great importance to simplify the update process and improve efficiency.

Goran Jurković and Vlado Sruck (2007) found that the performance of the system software update is based on the software agent entering the program memory directly, and an onboard computer was built in the system based on the ATMEL processor embedded with self-modifying FLASH memory of the program. Yang Jingzhe (2014) from the Beijing Institute of Technology has developed a CAN bus-based bootloader that can reliably update the program. However, the superior protocol the boot loader uses is not universal, which can result in poor portability. Wang Qi (2016), a researcher at the University of Post and Telecommunications in Nanjing, suggested the concepts of permanence in the boot and the minimal bootloader to improve the security of the online update system. But its approach complicates the process. Daniel Bogdan (2017) studied the need for an integrated flash bootloader embedded in the system, which can effectively reprogram the ECU to guarantee the minimum bugs in a system. According to Peng Xie and Bing Zhou (2018), the flash bootloader is the main part of the ECU platform software. It is the basic function

of the product under development and after-sales. It supports automatic flash. The CAN bus is the main network of the vehicle, connecting the entire network. A full-featured boot loader can speed up program development. Santi Nuratch (2017) developed a convenient framework for embedded developers that was formulated on development of a rapid embedded firmware. They designed a bootloader that works as a flash programmer (self-programming) running on the MCU. Compared to traditional methods, with the advantages of the proposed tool, embedded programmers can develop and verify their firmware in an swift way. Lubomir Bogdanov and Ratcho Ivanov (2019), in their study found that the firmware of the microcontroller can be updated via Wi-Fi. The bootloader data stream is transmitted via Wi-Fi. For this, a suitable bridge device that connects the UART interface to the world wide net and advanced flash memory applications is needed.

Wang Zhiqiang (2020) designed a boot loader software that can correctly guide the application to jump and run, and conveniently and accurately perform code data downloads, on-site updates and application upgrades. Prashanth R. (2019) presented Flash ECU technology used in the automotive industry and its existing functions in the automotive and research markets. Use of Controller Area Network (CAN) and CAN with flexible data rate, called CAN FD protocol was taken to perform flash memory measurement on ECUs. Nadhir Mansour Ben Lakha (2021) says that in modern cars, various safety-oriented mechanisms are implemented through CAN. These mechanisms carry out critical safety functionalities. If CAN reliability is not established, normal operation of these functions cannot be guaranteed.

2. PRELIMINARY DATA COLLECTION

The publications database can be accessed through the university library portal or through personal registration on the website. The following section contains a list of the keywords used. The above-mentioned document is articulated by sending the query to the Scopus repository.

2.1 Important keywords

The important keywords for the search were **"Boot Loaders" OR "Bootloader" AND "Firmware Updates"**. The top 10 keywords are shown in Table 1.

Table 1: List of keywords

Keywords	Number of Publications
Boot Loaders	55
Bootloader	43
Firmware	30
Embedded Systems	26
Computer Operating Systems	16
Microcontrollers	16
Cryptography	15
Internet Of Things	13
Controllers	12
Firmware Updates	11
Security	11

Source: www.scopus.com (data obtained on May 13, 2021)

Researchers have published 64.62% papers in conference proceedings, 17.69% papers in journals, 16.15% in book series and 1.54% in reference books as in Table 2.

Table 2: Publication type

Publication Type	Number of Publications	Percentage out of 130
Conference Proceeding	84	64.62 %
Journal	23	17.69 %
Book Series	21	16.15 %
Book	2	1.54 %

Source: www.scopus.com (data obtained on May 13, 2021)

2.2 Highlights of preliminary data

The prefatory investigation in our paper is done based on the keywords that extricated 130 publications from the database of Scopus. Documents such as conference reports, journal articles, book series and books were accessed for the research area of boot-loading microcontroller through

serial port from 2011 to 2021. The number of publications annually is shown in Table 3. The analysis based on the same is shown in Figure 1.

Table 3: Annual publication count

Year	Publication Count
2011	10
2012	9
2013	14
2014	11
2015	10
2016	9
2017	18
2018	13
2019	19
2020	13
2021	4
Total	130

Source: www.scopus.com (data obtained on May 13, 2021)

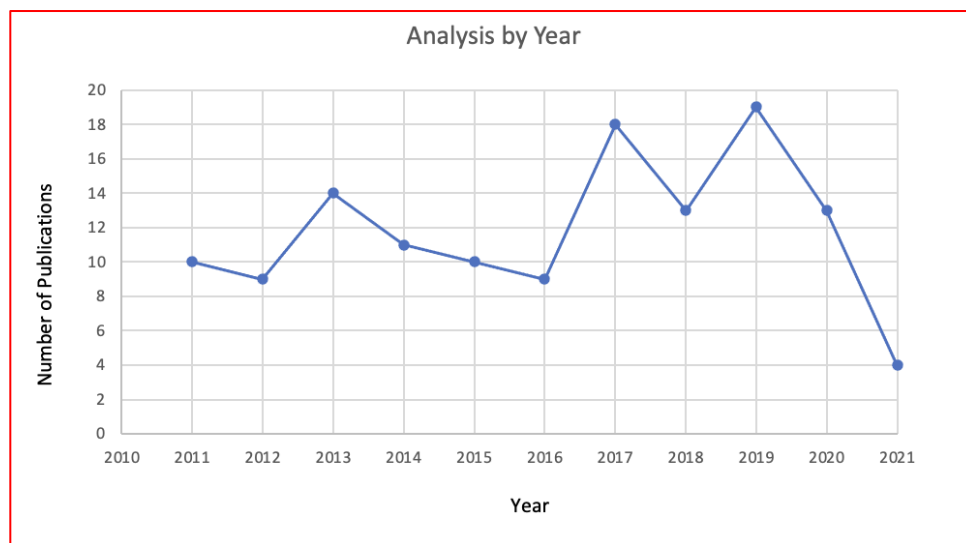


Figure 1: Yearly publishing trend

2.3 Data investigation

The bibliometric review carried out reveals the nature of the literature available in the following section, which highlights the distinction of the literature available using the geographical spread and contributions of the various authors in whom the works were published and the statistics of membership .

3. BIBLIOMETRIC ANALYSIS

To perform the bibliometric analysis two ways were used:

- Geographical region analysis
- Statistics of affiliations, subject area, author statistics, document type and citation analysis.

3.1 Geographical region analysis

The geographic attention regions of the published works are shown in Figure 2, which was created with the GPS Visualizer tool from gpsvisualizer.com. The Chinese, Indian and American publications are the maximum. Figure 3 shows the contribution in publications from different countries.



Figure 2: Geographic locale of the study of Boot-Loading Microcontroller Through Serial Port

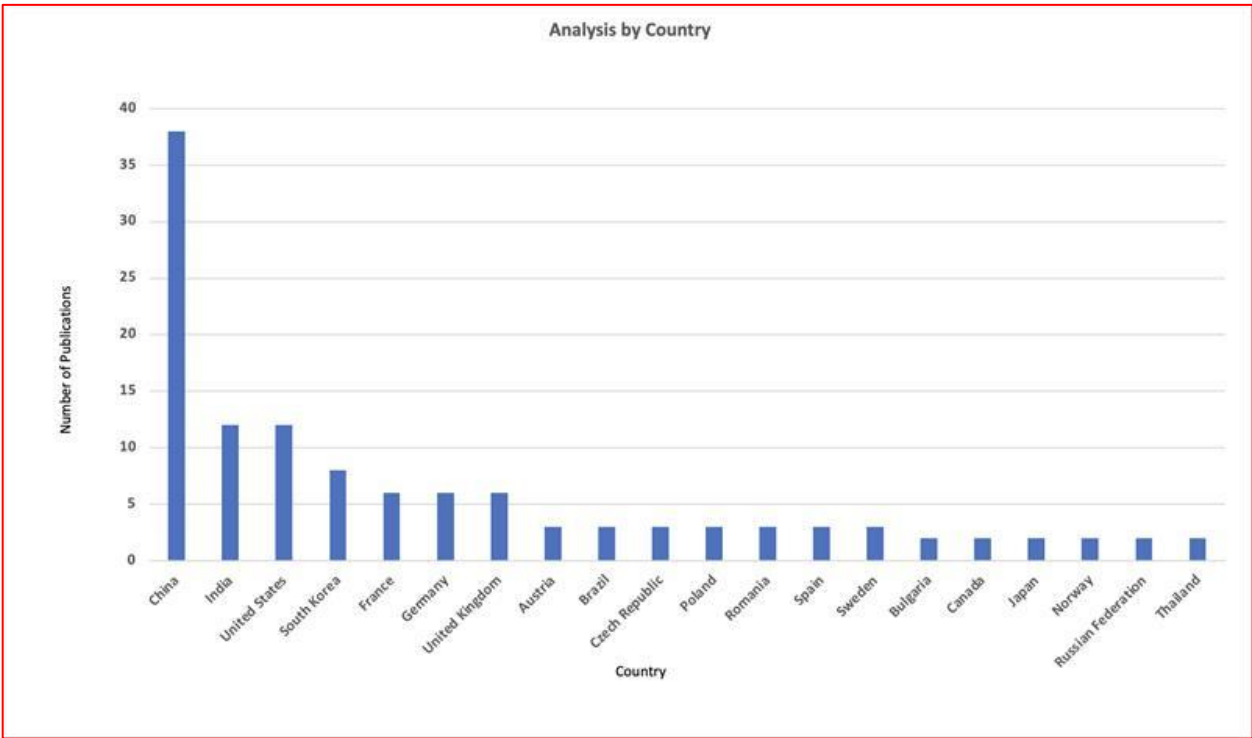


Figure 3: Analysis by country /Region

Source: www.scopus.com (data obtained on May 13, 2021)

3.2 Analysis based on subject area

The line-up according to subject areas is shown in Figure 4. The analysis suggests that utmost research papers are published in the field of engineering, computer science, followed by mathematics and physics and astronomy. Environmental science and chemical engineering are considerably less in the boot-loading microcontroller area.

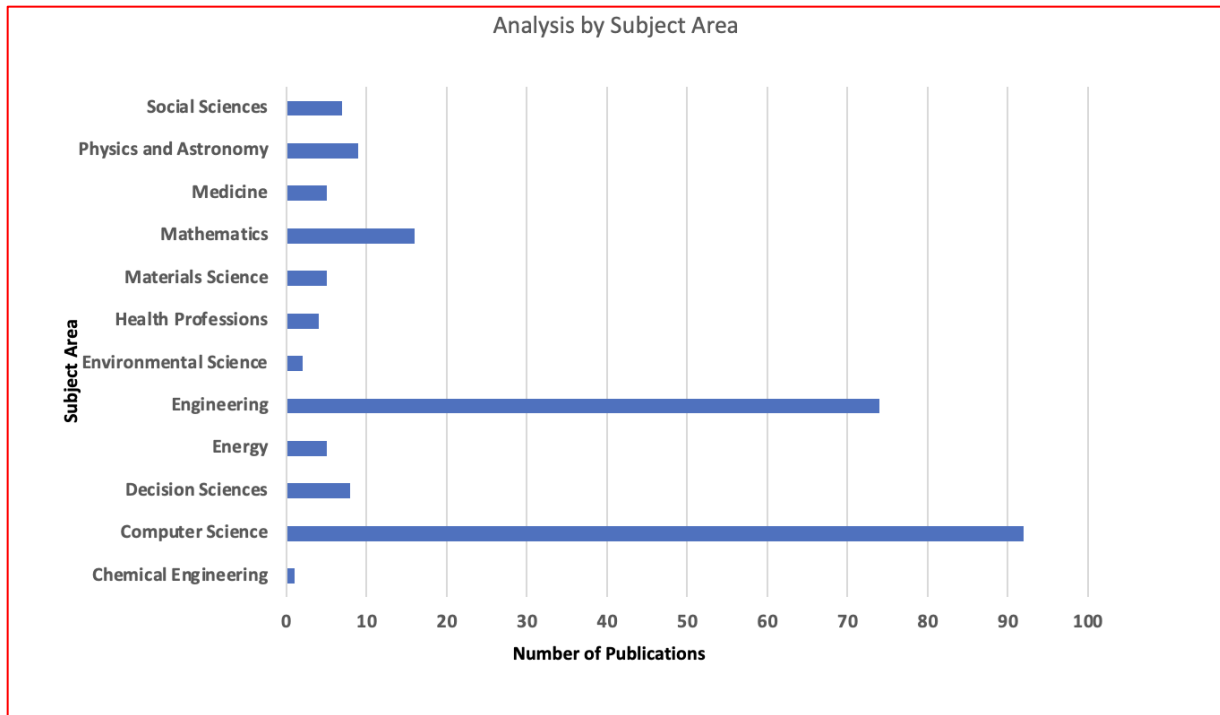


Figure 4: Analysis of papers published on Boot-Loading Microcontroller Through Serial Port based on subject area

Source: www.scopus.com (data obtained on May 13, 2021)

3.3 Analysis based on affiliation

The contributions of various universities around the world to the publication of research articles in the field of boot-loading microcontroller are shown in Figure 5. The research area of boot-loading microcontroller through serial port is dominated by the Chinese Universities listed in figure 5. The 20 best universities that publish in this area are shown.

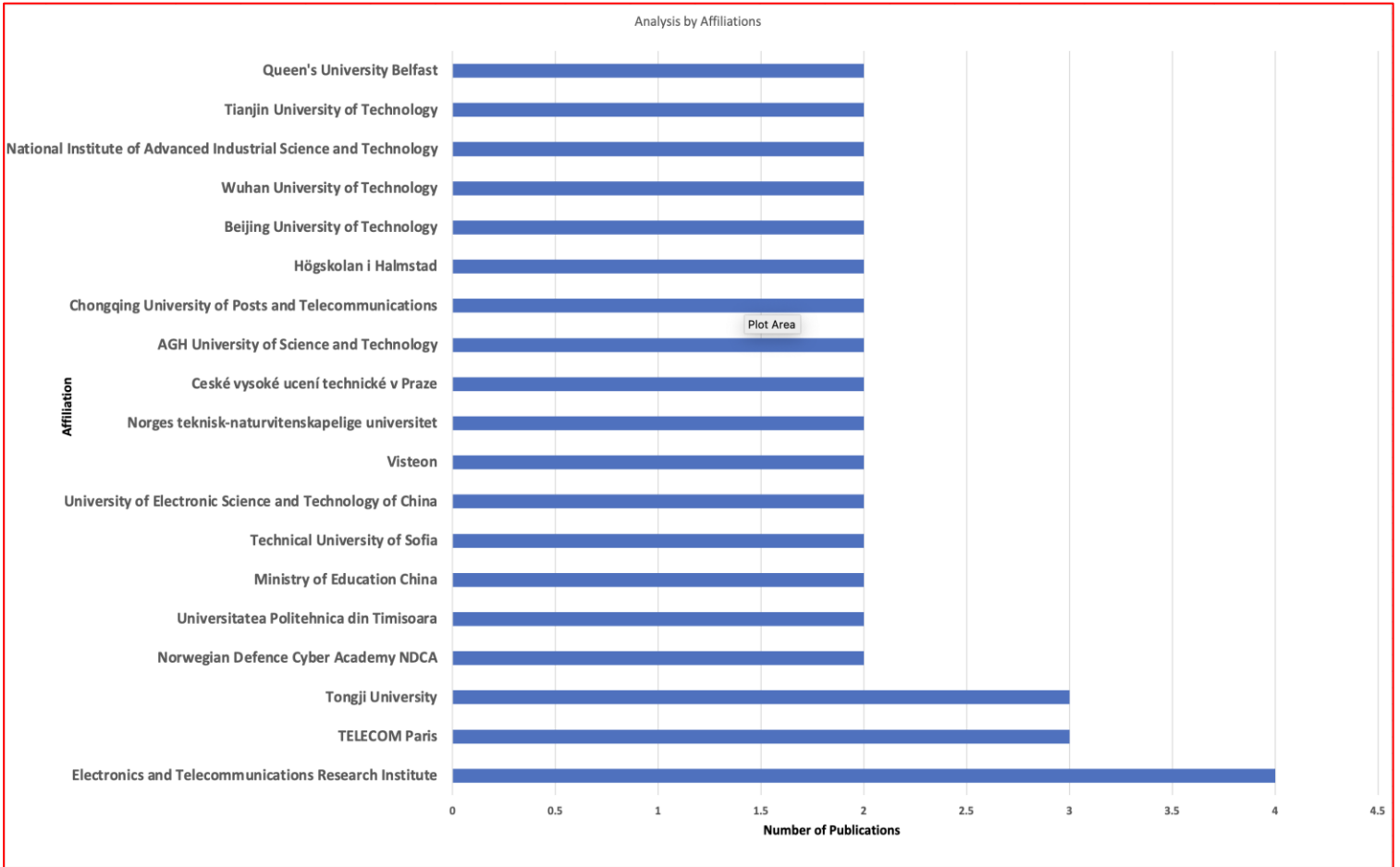


Figure 5: Analysis based on affiliations for publications contributing in the field of boot-loading microcontroller through serial port

Source: www.scopus.com (data obtained on May 13, 2021)

3.4 Analysis based on number of publications per author

The most important contributions in the area of boot-loading microcontroller through serial port are shown in Figure 6. The first ten authors were considered based on the data available from the Scopus database.

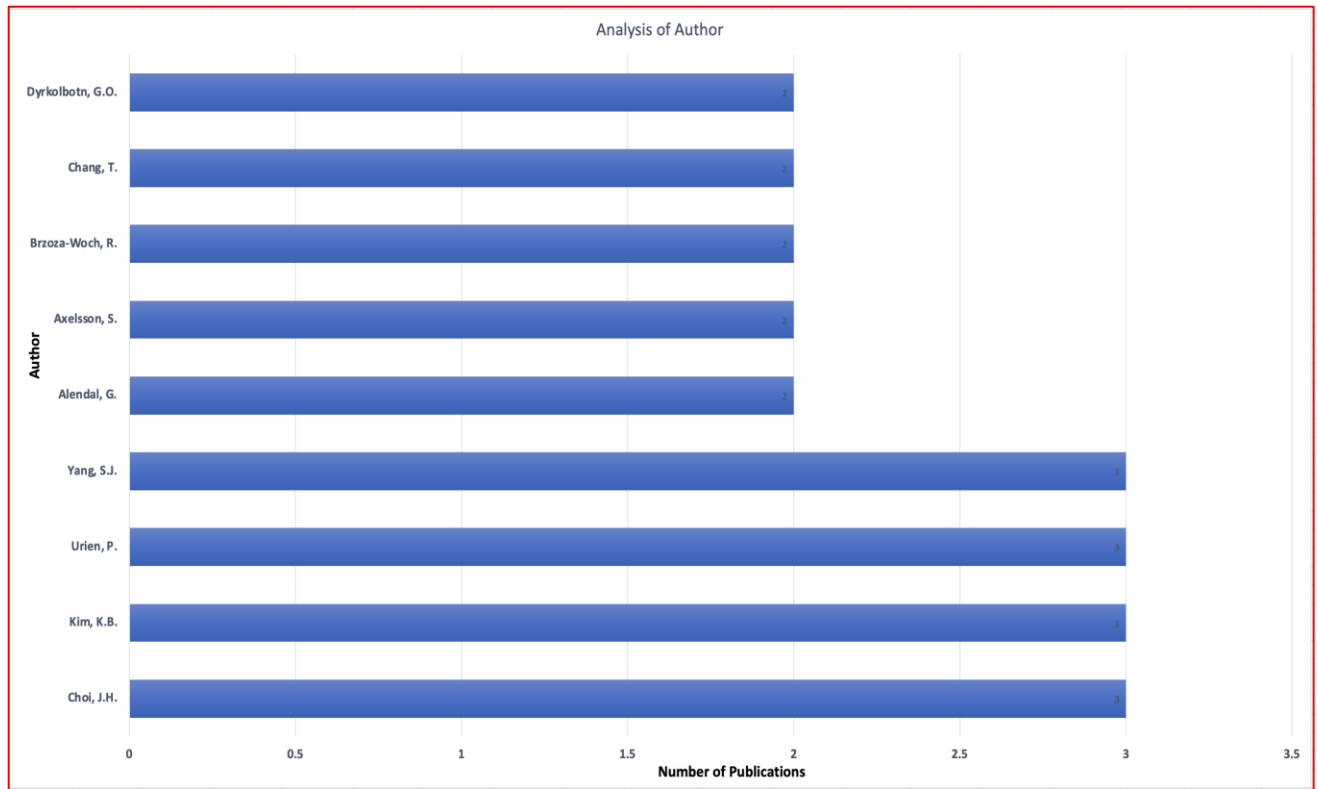


Figure:6 Key contributors in publishing

Source: www.scopus.com (data obtained on May 13, 2021)

3.5 Journal Statistics

The types of publication sources are shown in Figure 7. Figure 7 shows that 65% of publications are conference reports, 18% of publications are from magazines, 16% are from book series and 1% are from reference books.

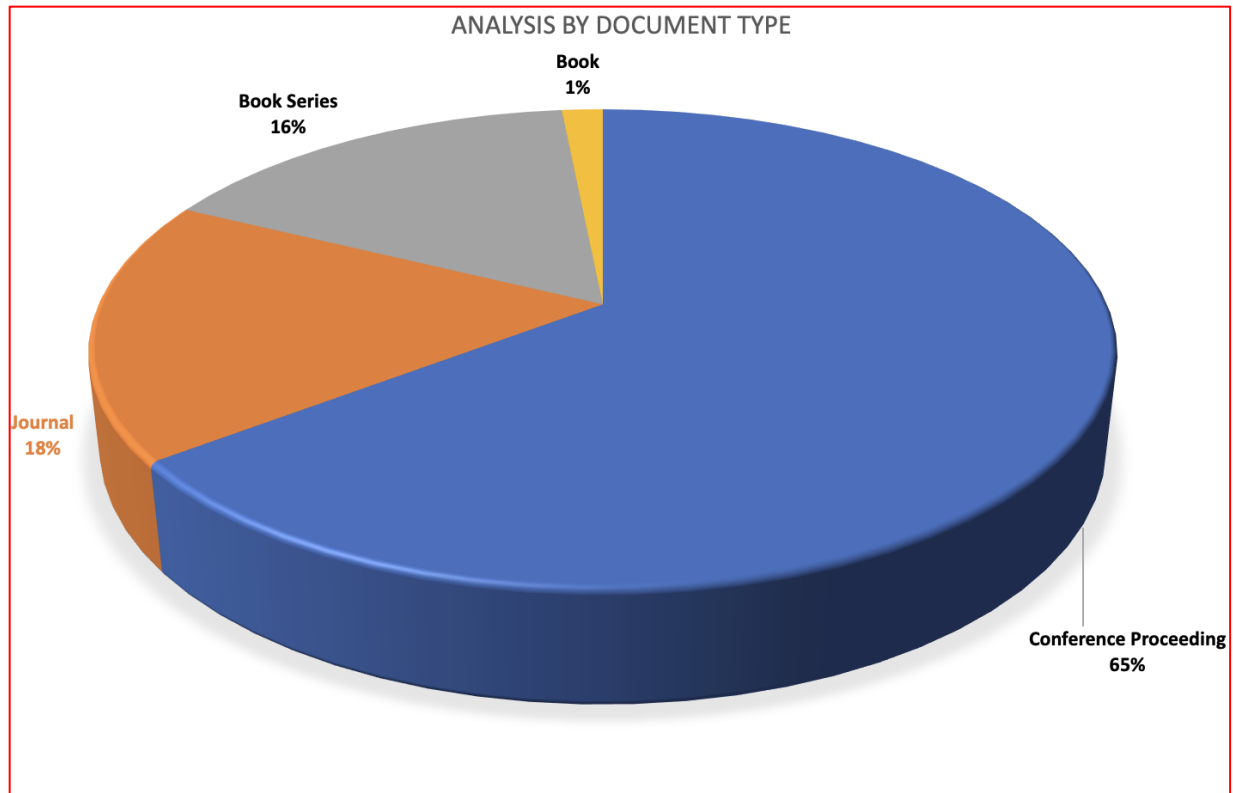


Figure 7: Analysis based on document type.

Source: www.scopus.com (data obtained on May 13, 2021)

3.6 Network Analysis

The interrelationship between the various statistical quantities is shown by the network analysis carried out with the 'Gephi' tool. Gephi is basically an open source software that is used to group and manipulate the available data. Keywords, font, publication title, publication year, affiliations, author are represented by nodes and frames. Various parametric combinations of data extracted from Scopus are used to create the clusters shown in Figures 8-10. Figure 8 shows a network based on affiliations, language, and post type. It has 35 nodes and 31 edges. Figure 9 proclaims a group by year and subject area. It has 44 nodes and 38 edges. Figure 10 proclaims a set of keywords and title of source. It has 48 nodes and 44 edges. Fruchterman Reingold layout was used along with manual adjustments for the layout while clustering.

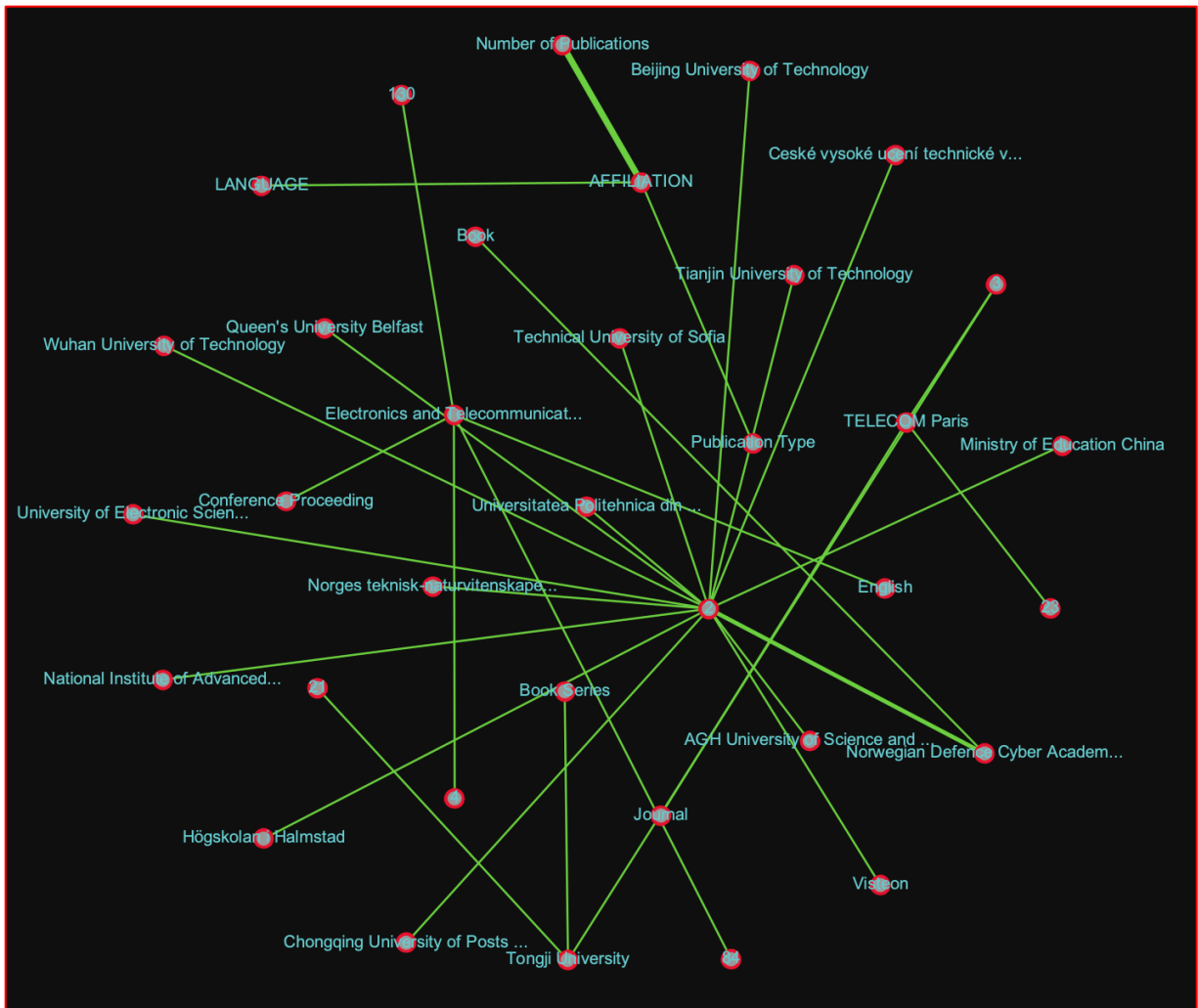


Figure: 8 Cluster of affiliations, language and publication type



Figure:10 Cluster of keyword and source title

3.7 Citation Analysis

The honourable mentions obtained per journalist (top ten scanned) in the area of boot-loading microcontroller through serial port are given in table 5. Authors and their citations till date of the extracted data are shown.

Table 5: Citations per author with maximum citations in the area of boot-loading microcontroller through serial port

Authors	<2017	2017	2018	2019	2020	2021	Total
Yang S.J., Choi J.H., Kim K.B., Chang T.	3	5	7	2	2	1	20
Maskiewicz J., Ellis B., Mouradian J., Shacham H.	4	7	3	3	3	0	20
Mansour K., Farag W., ElHelw M.	1	3	6	4	6	0	20
Redini N., Machiry A., Das D., Fratantonio Y., Bianchi A., Gustafson E., Shoshitaishvili Y., Kruegel C., Vigna G.	0	0	6	7	4	2	19
Sinha K., Kemerlis V.P., Sethumadhavan S.	0	0	4	3	6	1	14
Singh G., Bipin K., Dhawan R.	6	2	2	2	2	0	14
O'Flynn C., David Chen Z.	3	2	1	2	4	1	13
Mowery K., Wei M., Kohlbrenner D., Shacham H., Swanson S.	6	3	0	2	2	0	13
Park J., Chung H., Lee S.	8	2	1	0	1	1	13
Lebedev I., Hogan K., Devadas S.	0	0	0	6	5	1	12

Source: www.scopus.com (data obtained on May 13, 2021)

3.8 Statistics by document source

Figure 11 proclaims the boot-loading microcontroller through serial port booking statistics. From the extracted data available, it appears that the maximum number of publications is from the Applied Mechanics and Materials journal.

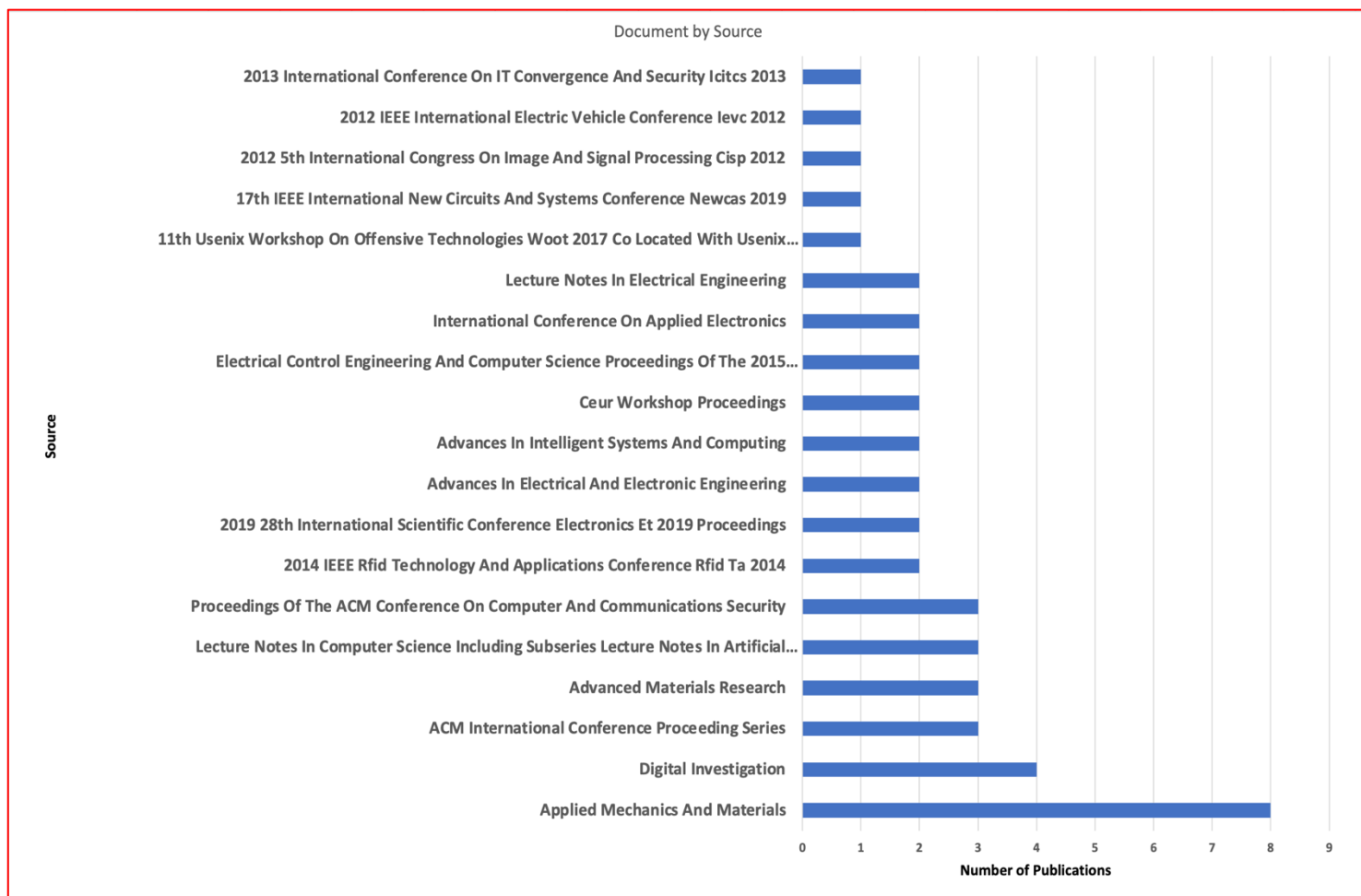


Figure 11. Statistics by document source.

Source: www.scopus.com (data obtained on May 13, 2021)

4. LIMITATIONS OF THIS STUDY

This bibliometric research conducted in the following article is based solely on the information from publications that were collected from the database of Scopus. In this regard, we could have considered some other journal articles, publications and book units from other sources, like Google Scholar, Web Science, Delnet, and Pearson. Yet, due to time constraints, this study was not incorporated in the above review/analysis. Nevertheless, this bar should be bridle in upcoming studies, and more details should be included in all the ongoing research to improve standardization. Although there are many other databases available for public use, the Scopus database is undoubtedly still the most widely database of all databases. This is the main reason for my research to be based solely on the data obtained through Scopus. Another limitation to consider is that this

research is limited to one language, English because it is the only shared language among the researchers writing the collected articles.

5. ACKNOWLEDGEMENT

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6. CONCLUSION

The bibliometric review of boot loading microcontrollers via the serial port entirely depends on the data collected from Scopus, and shows that the largest contribution to research publications in this field comes from the fields of computer technology and engineering, accompanied by the fields of mathematics. The purpose of this research is to have a good understanding of the development of the boot loading processes through serial port. To this end, a survey and detailed bibliometric study were carried out. It will provide a basic guide for budding researchers to understand the latest trends and help evaluate the research process and productivity. All necessary information comes from the Scopus repository. Bibliometric analysis shows that Chinese publications mainly come from conferences, magazines and series, followed by Indian and American publications. The analysis of the data collected from database of Scopus played a key role in guiding research related to the bootloading process of a microcontroller, here NXP S32K144 using serial ports.

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