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ABSTRACT

The survey and bibliometric research on dynamic target tracking by a mobile robot are discussed in this paper. The primary goal of this bibliometric analysis is to comprehend and analyze the scope of the literature in the field of mobile robots for obstacle avoidance, path planning and target tracking using Robot Operating System (ROS). The ROS contains various tools for data analysis, incorporates multiple robots and their sensors, and supports devices interaction for target seeking and localization in mobile robots. This detailed review was performed on various research publications about the mapping of the unknown field/environment by the ROS based wheeled mobile robot using sensors such as accelerometer, GPS. The bibliometric analysis is mainly focused on research papers found on various sources like Research Gate, Scopus etc., and elaborated using visualization tools such as GPS visualizer and VOS viewer. The bibliometric research reveals that the majority of publications come from Chinese journals, conferences, and papers, accompanied by US and Indian institute publications. The time-series dataset from 2010 to 13th May 2021. The subject of Computer Science makes the most important contribution, followed by Engineering and Mathematics.

Keywords: Mobile Robot; obstacle avoidance; ROS; accelerometer

1. INTRODUCTION

Mobile robots are becoming increasingly popular in industries in the area of flexible manufacturing and shop floor automation. The biggest advantage of mobile robots is that they are intelligent and self-driven and do not need manual supervision. To achieve this automation, mobile robots must have a localization method or positioning system that can reliably estimate the robot pose –position and orientation– while still error-free. (Leondes, 2000).

The main limitation in this is to obtain precise knowledge of the robot's location in any environment. Other than the features seen by its sensors, a mobile robot investigating a new area has no absolute frame of reference for its position. Using different and recognizable points or landmarks is one of the possible

approaches. The major issue with this approach is the requirement of the object recognition technique. There are primarily two types of localization sensors used in mobile robot navigation systems. These sensors help in measuring the robot's acceleration, angular and linear velocities along the wheeled robot's body axes. The mobile robot direction and position can be predicted by combining sensor measurements from two sets of sensors based on measurement methodologies used: relative positioning sensors such as accelerometers, gyroscopes, and magnetometers and Absolute positioning is achieved via Global Positioning System.

A mobile robot is a system with many subsystems, including planning, perception, motion, and control, that work together to complete a task successfully (Piedrahita, Giovanny Andres., Guayacundo, Diana Marcela., IEEE Members 2006). The above subsystems enable the robot to deal with changing environmental conditions and respond to unexpected events.

Accelerometers measure linear acceleration. Accelerometers are used for specific purposes, such as to measure vibration and inclination. MEMS accelerometers have various useful features for motion and acceleration detection. Gyroscope sensors are used for measuring or maintaining rotational motion and can be used to determine the orientation and are found in most autonomous navigation systems. Magnetometer sensors measure magnetic dipole moment or magnetic field. Various magnetometers measure the strength, direction, or relative change of magnetic field at a particular position. The Global Positioning System (GPS) provides the user with location information based on longitude and latitude measurements. GPS is used to navigate in a variety of modes of transportation.

ROS is software that collects frameworks for robot software development. ROS is not an operating system; it just provides services like device control, hardware abstraction, transfer messages between the packet and process management. (Dipak Bore, Amit Rana, Nilima Kolhare and Ulhas Shinde, 2012).

It was demonstrated that after properly designing and constructing models of the mobile robot platform and the environments in which the robot is positioned, the simulation software could be used to control actual robots. The results of experiments and simulations in 3D and 2D based mapped environments demonstrate the robot's usability and functionality in the field. (Kenta Takaya, Toshinori Asai, Valeri Kroumov and Florentin Smarandache, 2016).

2. PRELIMINARY DATA COLLECTION

Various Publication records and databases can be accessed using library websites. Several methods are available to retrieve data from popular records and databases like Scopus, Research gate, Google Scholar etc. Scopus database access has been considered in this paper as it is the largest among the peer-to-peer based reviewed databases. A list of the keywords used is given in the section below.

2.1 Important Keywords

The major keywords required for the search were “Mobile robot” and “Obstacle Avoidance” or “ROS”. Table 1 shows the occurrence of various author keywords.

Table 1: Author Keywords

Author Keywords	Occurrence (Number of Publications)
Mobile robot	129
ROS	296
Obstacle avoidance	52
Gyroscope	13
Accelerometer	44

Source: http://www.scopus.com

There were 1334 English publications. The publications of different languages which have a publication count of more than 5 since 2010 are shown in Table 2.

Table 2: Publication Trends based on language from year 2010

Publication Language	No of Publications
English	1334
Chinese	23
Korean	9
Spanish	7
Turkish	6

Only Languages with more than 5 Publications since Year 2010 are listed here.

Researchers have published 875 papers in conference proceedings, 322 papers in journals, 181 papers in book series, 5 books and 1 trade journal as shown in table 3.

Table 3: Source type

Source Type	Total Number of Publications
Conference proceedings	875
Journals	322
Book Series	181
Book	5
Trade Journals	1

2.2 The Preliminary Data's Major Highlights

The preliminary investigation in this study is based on the keywords that were retrieved from 1384 Scopus publications. Documents such as journal papers, conference proceedings, trade journals, books, and books series were retrieved from 2010 to 13th May 2021 for the research area of Robotics and Obstacle avoidance. Count per year is as shown in Table 4. Analysis of the number of publications made per year is shown in Figure 1.

Table 4: No of Publication from year 2010-13th May 2021.

Publication Year	No of Publication
2021	59
2020	260
2019	248
2018	196
2017	156
2016	117
2015	92
2014	68
2013	66
2012	61
2011	32
2010	29
TOTAL	1384

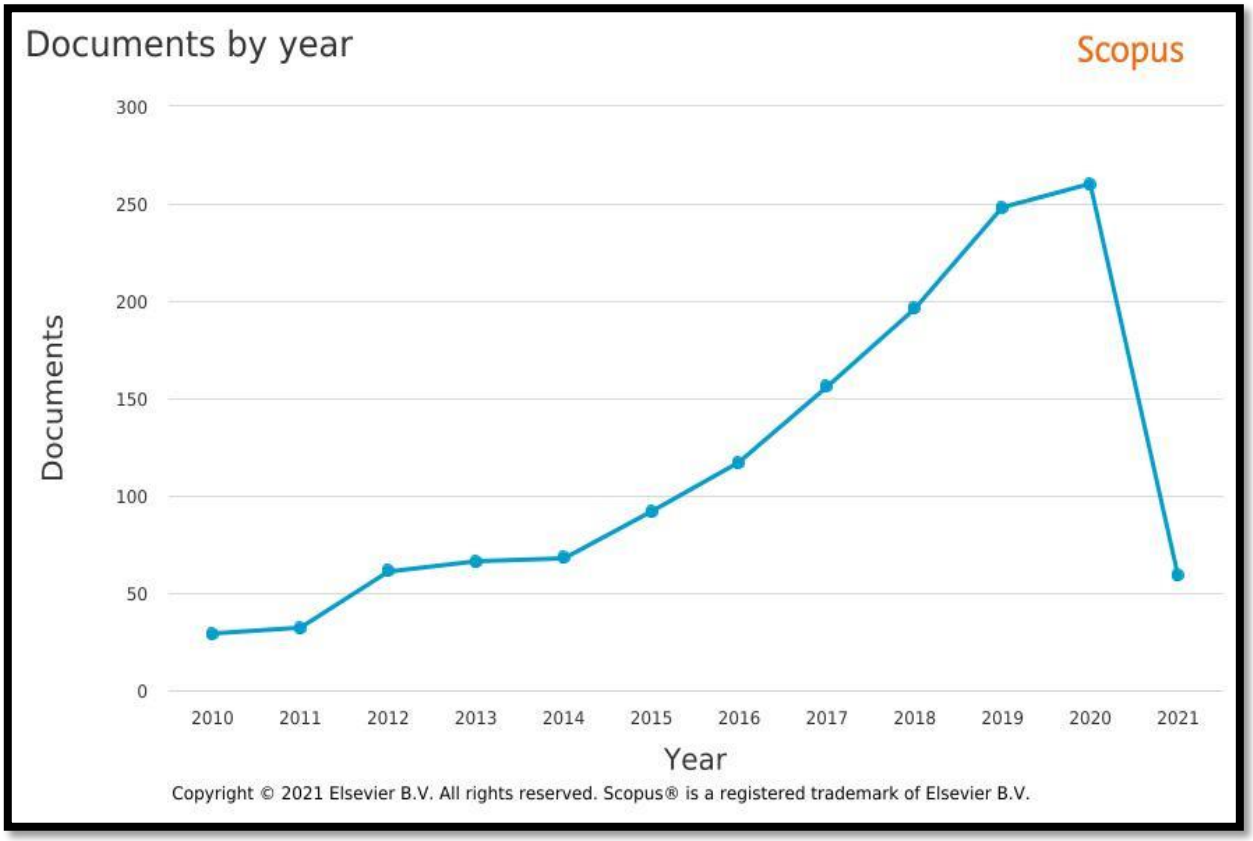

Figure 1: Publication count till 13th May 2021

2.3 Data Investigation

The conducted bibliometric review reveals the type of literature available. The next section will highlight the distinctness of the available literature and the geographical dispersion and contributions by different authors, where the papers were published and the affiliation statistics.

3. BIBLIOMETRIC ANALYSIS

To perform the bibliometric analysis two methods were used –

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

3.1 Geographical Region Analysis.

The geographical regions of the published papers are shown in Figure 2, which is drawn from the tool gpsvisualizer.com. Chinese publications are of the maximum number.

Figure 3 shows the contribution in publications by different countries.

Figure 2: Country with more than 50 Publications related to topic since Year 2010.

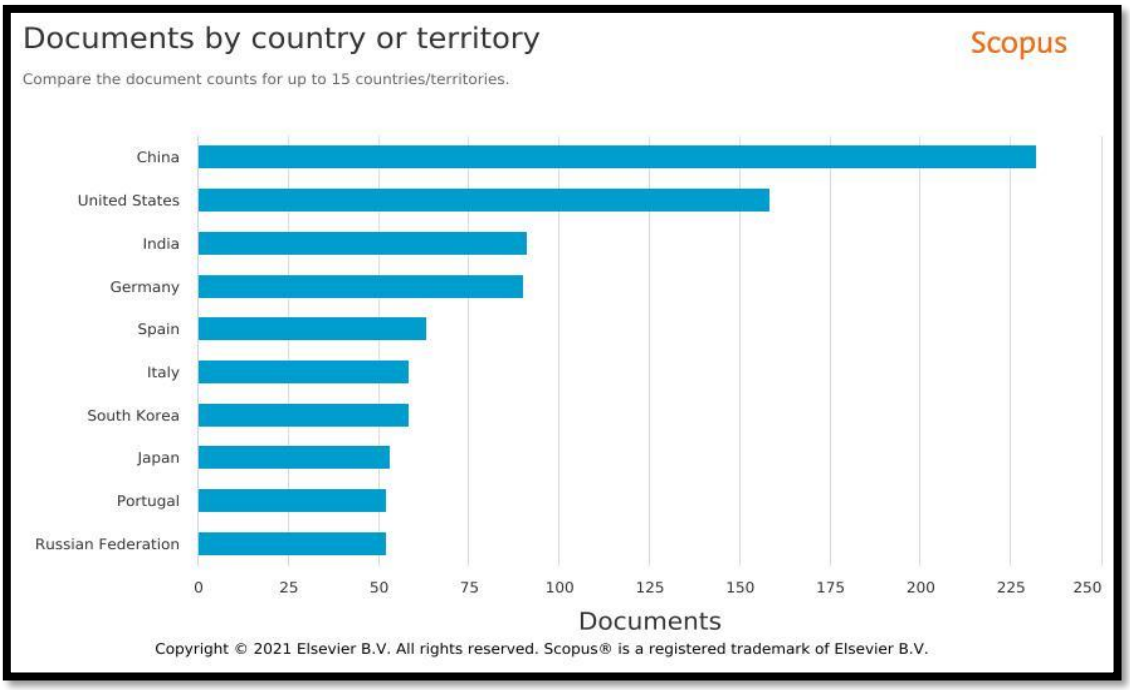

Figure 3: Analysis by Country/Region

3.2 Analysis Based on Number of Affiliations:

Contributions by different Universities worldwide in publishing research papers in Robotics as shown in Figure 4. Top twenty Universities publishing in this field have been shown. Major Institutes for publications related to robotics belong to Portugal.

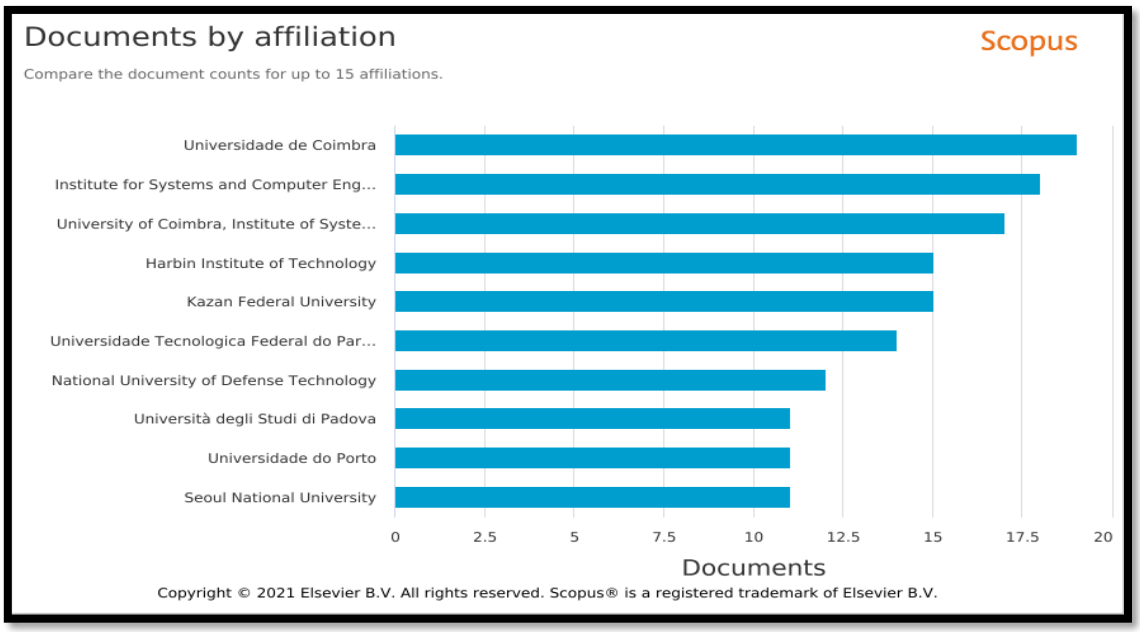

Figure 4: Analysis Based on Affiliation.

3.3 Subject-matter-based analysis:

Figure 5 depicts the analysis by subject area. According to the visualisation pie chart, the most research papers are produced in the fields of computer science and engineering, with mathematics following closely behind. In the discipline of Robotics, the amount of study done in the fields of Decision Science and Material Science is significantly less.

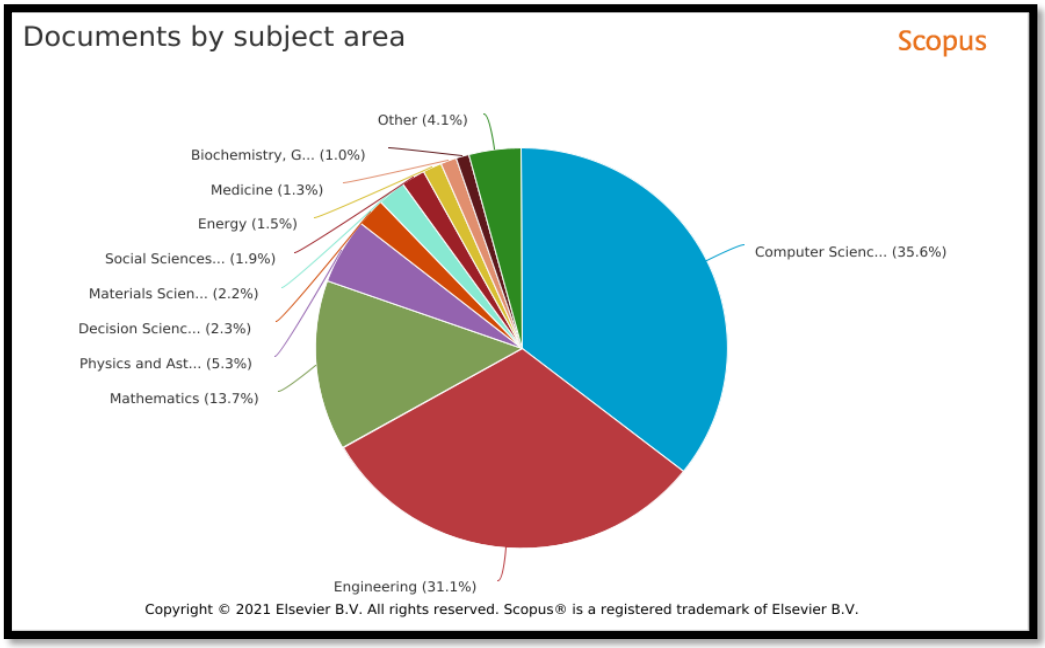

Figure 5: Analysis based on Subject Field.

3.4 Graphical Analysis based on Publications Per Authors:

Major authors contributing to the field of Mobile robot are depicted in figure 6. First ten authors were considered from the available accessed data from the Scopus database.

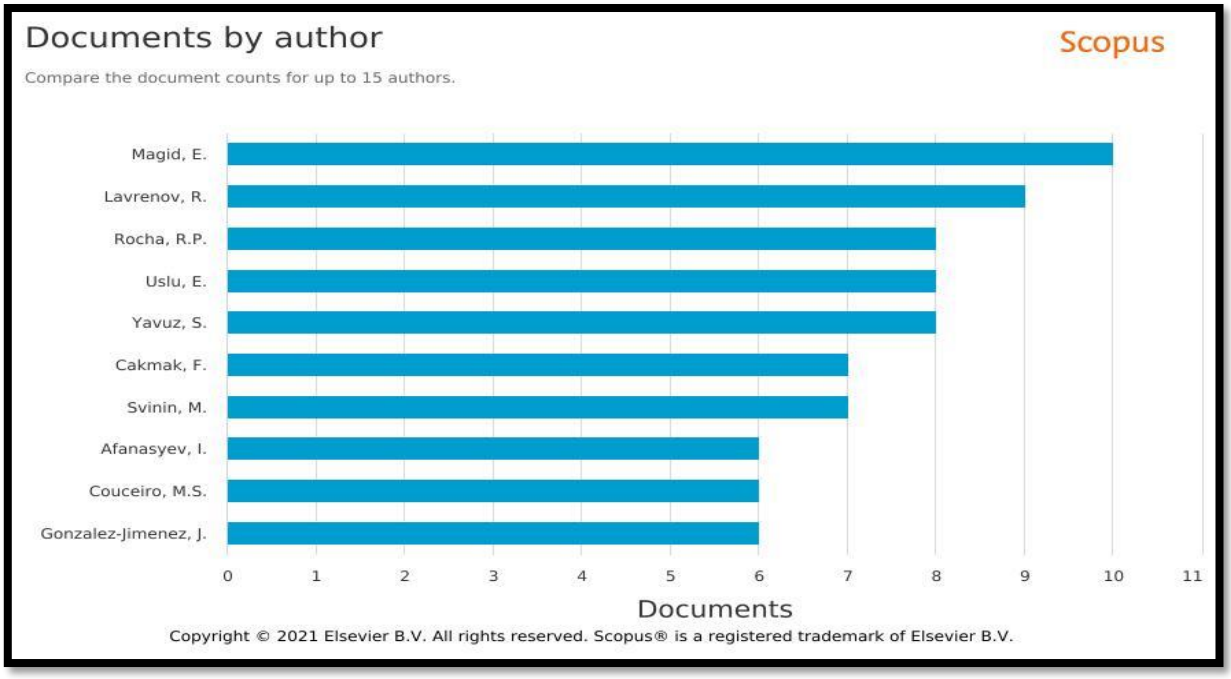

Figure 6: Publications per author

3.5 Journal Statistics

The publication source types are shown in Figure 7. It is clear from this figure that 69.7% publications are conference proceedings, 22.9% publications are article, 4.5% from conference review publications.

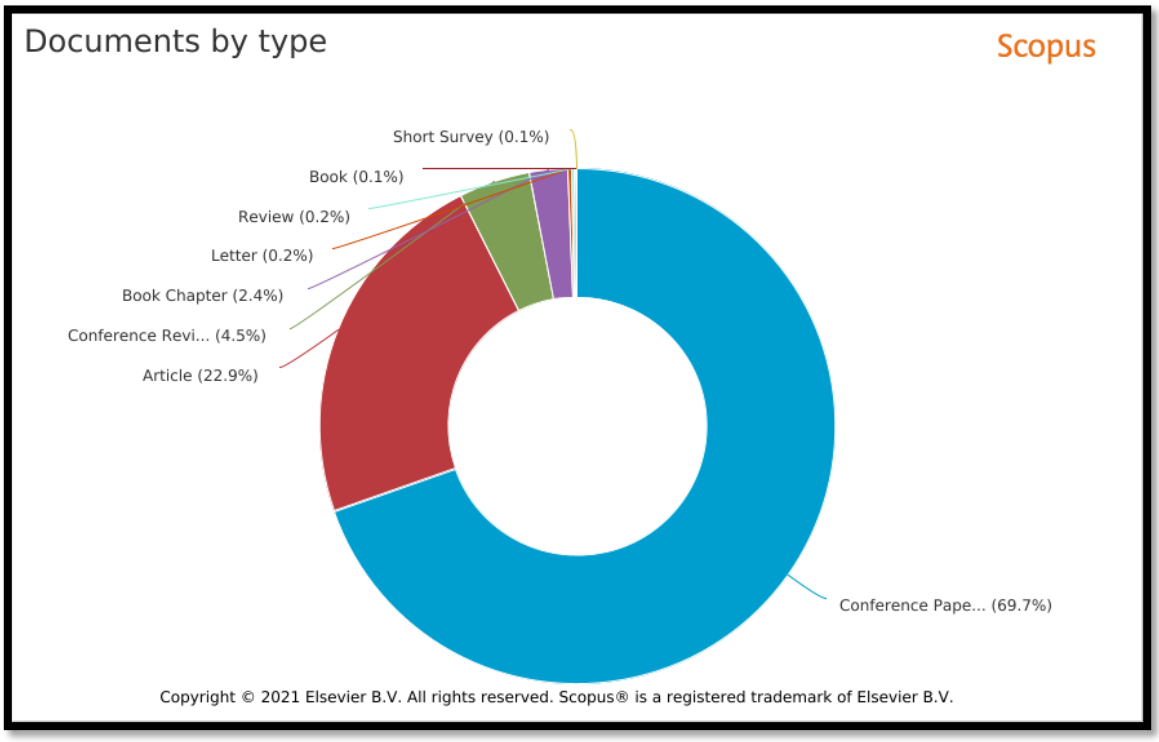

Figure 7: Publications by type

3.5 Network Analysis

The interrelation between the various statistical quantities is depicted using the network analysis carried out using the tool 'VOSviewer'. This software tool is used to construct and visualize bibliometric networks. These graphical networks may, for instance, include researchers, journals, or individual publications, and they can be constructed based on source type, keywords, publication title, year of publication, affiliations, author are represented by nodes and edges. Different parametric combinations of data extracted from Scopus are used for creating the clusters shown in Figures 8 & 9. on bibliographic coupling, citation, co-authorship re, or co-citation relation.

A minimum number of documents by an author is set at 4, so out of the 3845 authors, 27 have met the following threshold. (Figure 9). A minimum number of occurrence of keywords is set at 8, so out of the 2682 keywords, 67 has met the threshold. (Figure 8)

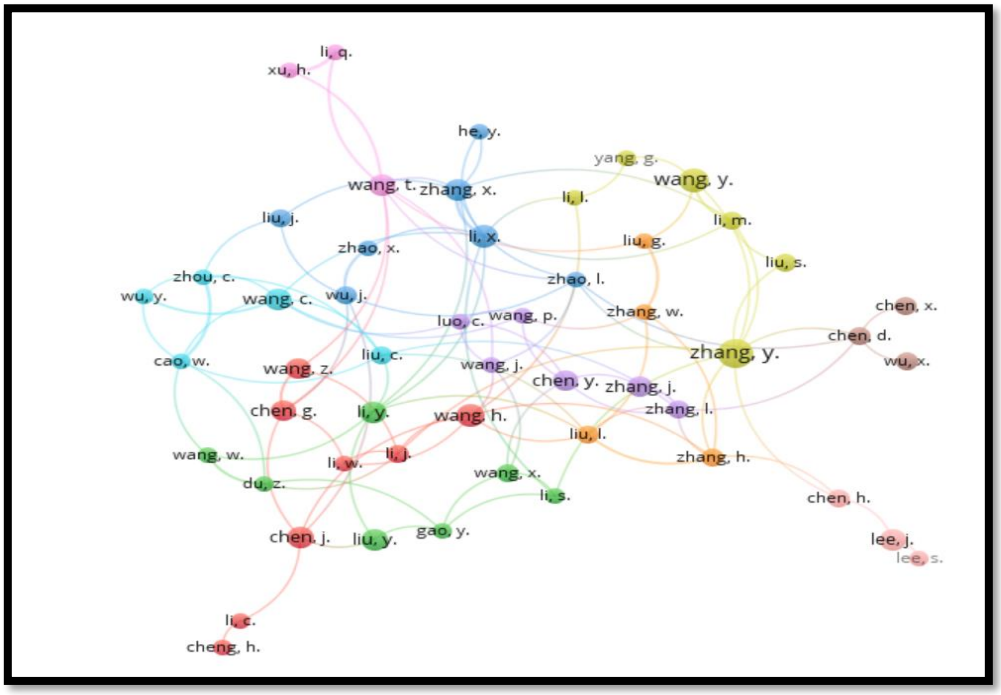

Figure 8: Network analysis based on Co-Author.

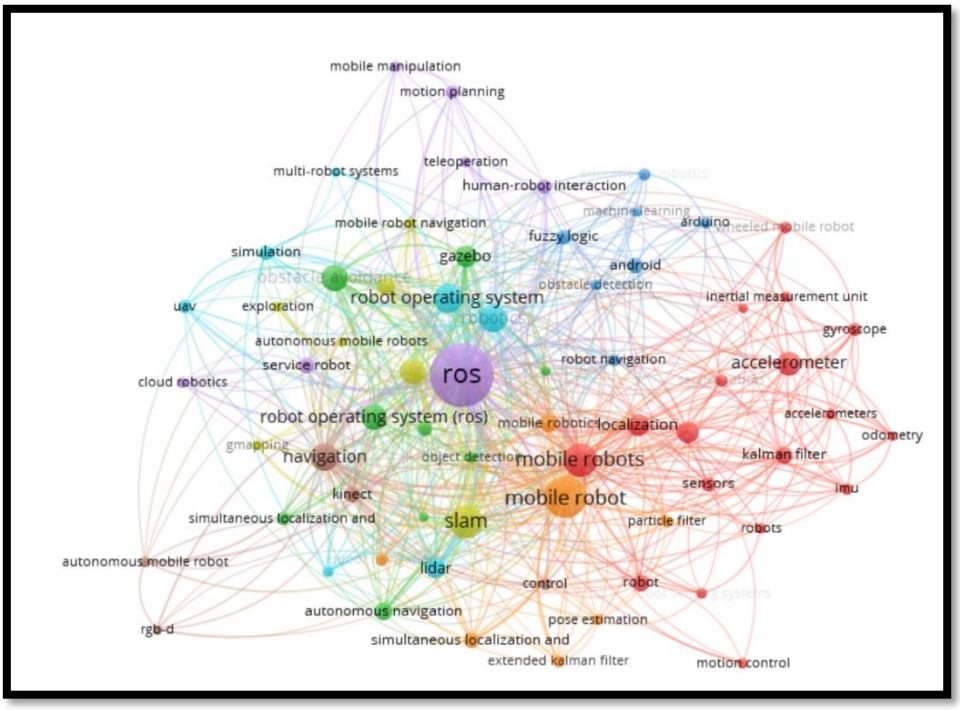

Figure 9. Network analysis based on Author Keyword

The citations obtained per author (first ten considered) in field of Mobile robots are mentioned in Table 5. Authors and their citations till date of the extracted data are shown.

Table 5: Citations per author with maximum citations in Robotics

Author	<2017	2017	2018	2019	2020	2021	total
Arumugam R., Xiaojun W., Baskaran K., Kong F.F., Bingbing L., Kumar A.S., Kit G.W, Enti V.R, Meng K.D.	**114**	**35**	**35**	**31**	**21**	**10**	**132**
Xu Z., Bai K., Zhu S.	**90**	**36**	**43**	**26**	**19**	**3**	**127**
Chitta S., Sucan I., Cousins S	**55**	**16**	**29**	**39**	**49**	**18**	**151**
Yan Z., Subbaraju V., Chakraborty D., Misra A., Aberer K.	**87**	**37**	**22**	**20**	**21**	**4**	**104**
Rehder J., Nikolic J., Burri M., Gohl P., Furgale P.T., Leutenegger S., Siegwart R.	**43**	**33**	**38**	**29**	**18**	**0**	**118**
Munaro M., Basso F., Menegatti E.	**62**	**19**	**13**	**18**	**8**	**2**	**60**
Stoyanov T., Magnusson M., Andreasson H., Lilienthal A.J.	**36**	**14**	**16**	**20**	**14**	**7**	**71**
Moore T., Stouch D.	**3**	**7**	**14**	**19**	**32**	**12**	**84**
Bogoslavskyi I., Stachniss C.	**0**	**8**	**14**	**23**	**27**	**9**	**81**
Diaz-Del-Rio F, Romero-Ternero M.C, Iigo-Blasco P, Cagigas-Muiz D, Vicente-Diaz S	**29**	**7**	**15**	**15**	**7**	**2**	**46**
Lee B.G., Chung W.Y.	**28**	**6**	**12**	**13**	**9**	**4**	**44**

4. Limitations of This Study

For the aim of bibliometric review, various keyword combinations were employed to search the Scopus database. This study was unable to include a few major articles, journals, and research papers that were not available in the Scopus database.

5. CONCLUSIONS

The bibliometric study of Robotics, which includes topics like obstacle avoidance, mobile robots, and ROS apps, is entirely focused on data derived from research paper visualisation websites like Scopus. According to the review, Computer Science makes the most contribution in terms of academic publications, followed by Engineering and Mathematics. This bibliometric study reveals that 1384 publications are from the Scopus database, of which 1334 publications are published in English from 2010 to 13th May 2021. By constraining the investigation time of the Scopus database to the most recent 11 years and finding that as many as 1384 publications getting published during this period, it can be concluded that there is a dependable advancement

in the number of publications. The majority of publications come from journals, conferences, and papers published in Chinese publications, followed by the United States and India. According to the results of the bibliometric analysis conducted in this report, researchers from countries such as China and the United States were the main research contributors in this field, which can aid in the advancement of mobile robots and obstacle avoidance.

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