

## Research trend on Robotics during 2012-2021: A scientometric analysis

\*S. Ravichandran, \*\* Dr. N. Siva, \*\*\* Dr.S.Vivekanandhan

\*Library Assistant Grade-1, SRM Institute of Science and Technology, Kattankulathur, Chengalpet, Tamilnadu, India. Pin- 603203, Mobile: 9952054226, Mail:[ravichas2@srmist.edu.in](mailto:ravichas2@srmist.edu.in)

\*\*Deputy Librarian, SRM Institute of Science and Technology, Kattankulathur, Chengalpattu, Tamilnadu, India. Pin: 603203, Mobile: 9840133850, Mail: [sivan@srmist.edu.in](mailto:sivan@srmist.edu.in)

\*\*\*Deputy Librarian, SRM Institute of Science and Technology, Kattankulathur, Chengalpet, Tamilnadu, India. Pin: 603203, Mobile: 9840133850, mail: [vivekans@srmist.edu.in](mailto:vivekans@srmist.edu.in)

**Corresponding author:** S.Ravichandran

### Abstract:

The present study aims to analysis the research productivity trend on the title “Robotics” research publications worldwide during 2012-2021 on the base of the Scopus database a total of 26862 research publications. It found that the maximum 4076 (74.46%) research were published in the year 2019, The compound annual growth ratio is 12.22. the maximum RGR 0.81 has been recorded in the year 2013 and a minimum RGR 0.16 has been counted in the year 2021 in order decreasing trend, while the maximum doubling time 4.36 has been counted in the year 2021 and the minimum doubling time 0.85 has been counted in the year 2013 in order increasing trend. Conference paper with 15680(58.37%) records counted, the maximum subjects with 17712 (78.84%) research publications have been founded on Computer Science. the author Ceccarelli, M. the United States secure first position contributed 51(13.42%) research publications, the maximum institutions with 467(17.83%) research publications were contributed by the Chinese Academy of Sciences, and The United States was secured 1st rank with 5795 (27.79%) research publications. The maximum 1048(22.24%) times robotics Journals in Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics. The time series analysis research publications in the year 2025 is around are equal to 3786 publications and the year 2030 is around are equal to 4336 publications is increasing trend. The highest cited paper 1623 Amjadi, M., (2016) Stretchable, Skin-Mountable, and Wearable Strain Sensors and Their Potential Applications: A Review, *Advanced Functional Materials*, 26(11):1678-1698.

**Keywords:** Scientometrics, Robotics, Compound annual growth rate, Relational citation index, Relative growth rate and doubling time.

### Introduction

The subject of Robotics is extremely relevant in today’s engineering curriculum because of the robots ability to perform tireless dangerous jobs. A robot is meaningful only when it is meant to

relieve a human worker from boring, Unpleasant, hazardous, or too precise jobs. A robot is normally designed to assist a human worker. In contrast to the general belief, a robot is actually not as fast as human in most applications it however, maintain the speed over a very long period of time. As a result, productivity increases if the number of pieces to be produced is very large, moreover the intelligence of todays most advanced robot is now here near human intelligence Thus, the introduction of a robot without real understanding of its benefits will be disastrous and is not advisable.<sup>1</sup>

Robotics is the branch of science and engineering and its treaties as the design, construction, operation, and use of robots. The science of robots by which humans working in this area are called robotics. Robotics is the science and technology of robots, their design, manufacture, and application. Robotics requires a working knowledge of electronics, mechanics, and software, and is usually accompanied by a large working knowledge of many subjects. Robotics is the study of robots, robots are machines that can be used to do jobs. Some robots can do work by themselves and other robots must always have a person telling them what to do. “Although the science of robotics only came into existence about in the 20thcentury, the history of human invented automation has a much longer past. In fact, the ancient Greek engineer Hero of Alexandria, formed two texts, Pneumatic, and Automata that testify to the existence of hundreds of different kinds of “wonder” machines capable of automated movement. Of course, robotics in the 20th and 21st centuries has advanced radically to include machines capable of assembling other machines and even robots that can be mistaken for human beings.

Just as giant talus was entrusted with the task of protecting the island of create from invaders in the industrial age a mechanical creature (automation) has been entrusted with the task of substituting a human being in subordinate labor duties. This concept was introduced by the Czech play wright Karel Capek who wrote the play Rossum’s universal Robots (R.U.R) in 1920. On that occasion he coined the term robot- derived from the term robot that means executive labor in slay language – to denote the automation built by Rossum who end up by rising up against human kind in science fiction tale. The word robotics was accidentally coined by science fiction author Russian Isaac Asimov in his 1940 story “Liar!” Science fiction authors throughout history have been interested in man’s capability of constructing self-motivating machines and life forms, conceived the robot as an automation of human appearance but devoid of feelings. Its behavior was dictated by a positronic brain programmed by a human being in such a way as to satisfy certain rules of ethical conduct.<sup>2</sup>

### **Scientometrics Study**

Scientometric is one of the truly inter disciplinary research fields to extend almost all scientific fields. In addition many extensive bibliometric studies of important science fields appeared during the last two decade. At presents, the connotation of bibliometric turns out to be the science of measurement relating to documents. The word measurement mean the application of mathematical and statistical techniques to find out growth of document, scattering or literature in various types of documents, publication of documents by an author, impact of document and so on. **Cole and Eales (1917)**<sup>3</sup> in their publication on history of comparative anatomy, applied

statistical methods for analyzing the literature are called it statistical analysis. The most important contribution was made by **Hulme (1923)**<sup>4</sup> when he published the book statistical bibliography, this term continued to be used for statistical measures till the end of 1960s. **Ranganathan (1948)**<sup>5</sup> coined the term librmetry to denote measurement of various library activities and service using mathematical and statistical technique. **Alan Prichard (1969)**<sup>6</sup> coined the term bibliometric to denote Application of mathematical and statistical methods to book and other media, process of written communication and of the nature and course of a discipline. **Van Raan (1997)**<sup>7</sup> According to scientometric research is devoted to Quantitative studies of science and technology. So that this paper aims to analyze the contribution of wastewater management research publications are published in Scopus database during the period of 2010 – 2019.

### **Literature review**

**Sab et al. (2018)**<sup>8</sup> analyzed the publishing trends of Indian Chemical Science research during 2002-2016 with the help of Web of Science database. The publication share of India was 5.46% during study was increased from 3.94 to 6.99. The average growth of 5.30% per year. International collaboration trend consistently increasing and the USA was the highest collaborative country. Computer Science was the broadest subject among all the subjects contributed the largest publication share of 67.69% articles. The maximum share of articles was with journal articles with 45213 articles and a total of 503 articles were registered as a highly cited paper with 100 to 100+ citation per articles.

**Gupta et al. (2017)**<sup>9</sup> have examined the publishing trends of world mobile research based on Scopus database during 2007-2016. A total of 140375 globally articles were founded for the study with an annual average growth rate of 1.68%. China was the largest globally contributing country with 20.52% articles and top 20 most productive countries published 95.05% articles globally during the period of study.

**Dhawan et al. (2016)**<sup>10</sup> conducted a scientometric study on research in the electronic publishing field during 2005-2014. The major findings of the study was a total 7010 articles published with 3.14% compound annual growth rate and averaged 1.08 citation per articles. The top 15 most productive organizations publication share was 5.72% and citation share is 12.73% during 2005-2014. The average productivity rate per organization during the study was low 26.7, citation impact per pater was 2.41, h-index was 6.93 and international collaborative share was 23.44% during the study period.

**Santhakumar and Kaliaperumal (2014)**<sup>11</sup> directed a scientometric study on mobile technology publications and focus on the growth and development of mobile technology in terms of publication output available on engineering index database during 2003-2012. They found that a total of 144567 publications were published. The average 14456.7 articles published per year and the highest number of publications 20318 were published in the year 2011. The most creative author was Wang. Wei who contributed 223 articles during the study. Institute of Electrical and Electronic Engineering (IEEE) New York (USA) was the highly donated institution with 1248

publications. The relative growth rate (RGR) has reduced from 2004(0.98) to 2012(0.13) and doubling time (Dt) has gradually enlarged from 2004(0.71) to 2012(5.15) throughout the study.

**Kumar (2014)**<sup>12</sup> analyze a scientometric study on digital literacy in online library information science and technology abstracts (LISTA) during 1997-2011. A total of 137 articles were published during the study period. 53.28% of articles focus significantly on digital literacy. Academic journal and periodicals 69.34% primarily publish articles on digital literacy in the field of library and information science. Triple authorship pattern 35.04% was dominating, 35-40 age group authors publish a high number of 39.42% articles. U.K. (27.01%) and U.S.A. (24.82%) were generated more numbers of articles. International journal of information and library review 8.03% have published a maximum number of articles.

**Ajay Kumar (2021)**<sup>13</sup> examined the research trend in robotics from 2009 to 2018: A scientometric analysis based on the Scopus database. A total of 97480 articles were published on the “Robotics” title in the world from 2009- to 2018. The highest 11950 (12.26%) articles were published in the year 2018, and the lowest 6980 (7.16%) articles were published in the year 2009. The maximum AGR of 15.36 was calculated in the year 2010 and the lowest AGR of -7.00 was calculated in the year 2012. The highest RGR has been counted as 0.77 and the lowest RGR of 0.13 has been calculated during the period of study. The relative growth rate was always in decreasing order and respective doubling was always in the increasing order during the period of study. Computer Science was the leading subject with 53675 articles. Chinese Academy of Sciences with 1577 articles was the highest contributed affiliation, the United States with 36159 was the leading country of publications.

**Gaud Nutan (2019)**<sup>14</sup> analyzed a Critical Analysis of the Scientific Productivity of the Robotics Research in India from 2009 to 2018. This paper describes the results of a scientometric study of “Robotics” research publications during the period of 10 years i.e. (2009-2018). A total of 4325 research papers. The annual growth rate of publications fluctuated trends. The maximum (1.23) relative growth rate was found in 2010; the highest doubling time (3.43) was recorded in 2018; the maximum number of papers were written by more than three authors i.e. 1657 research papers. The average degree of the author’s collaboration was (0.93). Krishna, K.M. was the most productive author with (51) research papers contribution. Out of a total of 16670 citations, 2718 citations were recorded in 2010 and a total of 4325 publications, 2704 (62.52%) of records were conference papers. The highest publications came from computer science subjects.

**Ravichandran and Vivekanandhan (2022)**<sup>15</sup> examined the Scientometric analysis of diabetics’ research output from the Scopus database from 1971 to 2020 in India. From a study of the Scopus database with a total number of 19756 research publications. During the study period, a maximum of 8323(42.13%) research publications are contributed in the block years 2016-2020. The relative growth rate is 0.86 in the block years 1971-1975 and 0.55 in the block years 2016-2020. At the same time doubling time found that 0.81 in the block years 1971- 1975 and 1.27 in

the block years 2016- 2020. A maximum of 15778(79.86%) research publications are contributed by article. The average degree of collaboration is 0.95. The average CC value is 0.62. The average CI value is 3.38. A maximum of 303(23.17%) research publications are contributed by Mohan, and a maximum of 597(18.27%) research publications are contributed by the all India institute of medical sciences, New Delhi. A maximum of 1010(35.84%) research publications collaborate country by United States.

**Ravichandran and Siva (2022)<sup>16</sup>** analyzed the Infertility research output in India from the Scopus database from 2012 to 2021: from the study the Scopus database with a total number of 3701 publications in India. The year-wise research publications contributed to Infertility research, a maximum of 462(15.04%) research publications are contributed in the year 2021. The United States is the most contributing top-ranking collaborator country with 184(32.03%) research publications. A maximum number of 43(13.15%) research publications are contributed by Kamath, M.S, and India with top-ranking authors. The average degree of collaboration is 0.92. A maximum of 2265(73.75%) research publications are articles in the document type. The average CC is 0.66, the average CI is 3.86, and the average MCC is 3.87. The study most contributed top-ranking All India Institute of Medical Sciences, New Delhi with 203(25.38%) research publications. Top-ranking Journal of Human Reproductive Sciences with 250(34.06%) research publications.

### **Objectives of the study**

The objectives of the study are to

- To analysis year - wise distribution of research publications.
- To examine the compound annual growth rate of publications.
- To calculate the relative growth rate and doubling time
- To identify the major document type and key word
- To analysis of the subject top 10 in the study.
- To find out the authors and organizations top 10 in the study.
- To find out the country and journals top 10 the study
- To identify the funding agency and language top 10
- To analysis the time series analysis and highly cited paper

### **Methodology**

The present study is based on the research output published on the topic Robotics during 2012-2021. The search string for collection of raw data is ((TITLE-ABS-KEY ("Robotics") AND TITLE-ABS-KEY ("Machine")) AND PUBYEAR > 2011 AND PUBYEAR < 2022) the total of 26862 records were counted on the Scopus database. The obtained data were analyzed and tabulated in an MS-excel sheet and tested by the various scientometric tools to fulfill the objectives of the study. The data was collected from the Scopus database on 18.04.2022.

## Data analysis

### Compound Annual Growth Rate [CAGR]

The Compound Annual Growth Rate [CAGR] is one of the useful measures to identify the growth, over the multiple time periods. It can be measure from the initial number of publications to ending number of publications. The mathematical formula of CAGR is used **Ashok Kumar and Gopala Krishnan (2013)**.<sup>17</sup>

$$\text{CAGR} = \left[ \frac{\text{Ending Value}}{\text{Beginning Value}} \right]^{\left[ \frac{1}{\# \text{ of Years} - 1} \right]}$$

### Relative Citation Index (RCI)

Relative citation index (RCI) was developed by the Institute of Scientific Information and examine the impact of different countries, institutions, authors and journals research publications. The scientific impact of leading countries was examined by using two relative indicators, namely citations per paper (CPP) and relative citations index (RCI). Citations per paper (CPP) are a relative indicator computed as the average number of citation per paper. To measure the both influence and visibility of a country research, the following formula has been used by **Bharvi Dutt and Khaiser Nikam (2016)**.<sup>18</sup>

$$\text{RCI} = \frac{\text{A Country share of the World Citations}}{\text{A Country share of the World Publications}}$$

RCI = 1 indicate that a country's citation rate is equal to the world citation rate

RCI > 1 indicate that a country's citation rate is greater than the world citation rate

RCI < 1 indicate that a country's citation rate is lower than the world citation rate

### H-Index

**Hirsch (2005)**<sup>19</sup> proposed the h-index is one of the alternatives to the standard bibliometric indicators for single scientists, it is defined below the table,

A scientist has index h if h of his or her N<sub>p</sub> papers have at least h citations each and other papers (N<sub>p</sub> – h) have ≤ citations each.

**Ye (2009)**<sup>20</sup> found that the **Glanzel-Schubert (2007)**<sup>21</sup> model was better than the **Hirsch and Egghe-Rousseau (2006)**<sup>22</sup> model to estimate the h-index of countries and other units. **Gupta and Bala (2013)**<sup>23</sup> discussed the h-index in the various acts of Epilepsy research in India. Differences among the various models of the h-index are,



**Various methods of *h*-index**

Model	Equation	Description
Hirsch	$h = \sqrt{(C / a)}$	C = Total Citations; a = Constant
Egghe-Rousseau	$h = P^{1/\infty}$	P = Total Publications; a > 1 is Lotka's Exponential
Glanzel-Schubert	$h = c P^{1/3} (CPP)^{2/3}$	c is a Constant; P = Total Publications CPP = Citations Per Publications

**Year - wise distribution of the Robotics Research Publications**

**Table 1 Year - wise distribution of the Robotics Research Publications**

S.No	year	Publications	%	Citations	%	Cited	%	Uncited	%	h-index	CPP	RCI
1	2012	1245	4.63	22567	8.26	356	8.42	889	3.93	71	18.13	1.78
2	2013	1560	5.81	24573	9.00	411	9.72	1149	5.08	67	15.75	1.55
3	2014	1745	6.50	25187	9.22	453	10.71	1292	5.71	67	14.43	1.42
4	2015	2102	7.83	33081	12.11	463	10.95	1639	7.24	79	15.74	1.55
5	2016	2238	8.33	33657	12.32	468	11.07	1770	7.82	72	15.04	1.48
6	2017	2756	10.26	35509	13.00	497	11.75	2259	9.98	69	12.88	1.27
7	2018	3409	12.69	42249	15.47	424	10.03	2985	13.19	84	12.39	1.22
8	2019	4076	15.17	30327	11.10	440	10.41	3636	16.06	67	7.44	0.73
9	2020	3786	14.09	19722	7.22	385	9.11	3401	15.03	48	5.21	0.51
10	2021	3945	14.69	6275	2.30	331	7.83	3614	15.97	23	1.59	0.16
	Total	26862	100.00	273147	100.00	4228	100.00	22634	100.00			
	CAGR	12.22										

Table 1 shows the year-wise growth of research publications in robotics during the ten -year study period between 2012 and 2021 with 26862 research publications. From the study, it is identified that the maximum of 4079(15.17%) research publications are contributed in the year 2019, followed by 3945(14.69%) publications in the year 2021, and 3786(14.09) publications in the year 2020. The average number of research publications per ten-year study period is 2686.2 research publications. This study identified that the growth of research publications in robotics is increasing and decreasing trend.

During the study period the highest citation with 42249(15.47%), and cited with 424(10.03%), uncited with 2985(13.19%). The h-index is 84, CPP is 12.39, and RCI is 1.22 in the years 2018, and the lowest citation with 6275 (2.30%), cited with 331(7.83%), uncited with 3614(15.97%), h-index is 23, CPP is 1.29, and RCI is 0.51. The compound annual growth ratio is 12.22.

**Relative growth rate and doubling time of publication**

The most important feature of science and technology in recent years has been calculated by the rate of growth. Scientific growth has been involved not only increase in manpower and financial investment. The relative growth rate is identified by the increase in number of publications per unit of time. The mean relative growth rate over the particular period of interval can be calculated in the following formula developed by **Mahapatra (1985)<sup>24</sup>**

$$R(a) = \frac{(W_2 - W_1)}{(T_2 - T_1)}$$

Where,

R (a) = RGR = the mean relative growth rate over the specific period of interval

W<sub>1</sub> = the logarithm of beginning number of publications/pages

W<sub>2</sub>= the logarithm of ending number of publications/pages after a specific period of interval

T<sub>2</sub> – T<sub>1</sub> = the unit difference between the beginning time and the ending time.

Here the year can be think about as the unit of time. The relative growth rate for the both publications and pages are calculated separately.

R (a) = Relative growth rate per unit of publications per unit of time

R (p) = Relative growth rate per unit of pages per unit of time

### Doubling Time [Dt]

The doubling time is the time taken for the doubling of the number of records actually published within a stipulated period. The doubling time is calculated from the relative growth rate (difference between the logarithms of beginning and end of the year from the study) and the natural logarithm number is used, the difference has a value of 0.693. Thus the corresponding doubling time for each specific period of interval and for both publications and pages can be calculated by the following formula,

$$Dt = \frac{0.693}{R(a)}$$

### Relative growth rate and doubling time of Robotics Research Publications

**Table 2 Relative growth rate and doubling time of Robotics Research Publications**

S.No	Years	Publications	Cum	W1	W2	RGR=(W2-W1)	Dt=(0.693/RGR)
1	2012	1245	1245		7.13		
2	2013	1560	2805	7.13	7.94	0.81	0.85
3	2014	1745	4550	7.94	8.42	0.48	1.43
4	2015	2102	6652	8.42	8.80	0.38	1.82
5	2016	2238	8890	8.80	9.09	0.29	2.39
6	2017	2756	11646	9.09	9.36	0.27	2.57
7	2018	3409	15055	9.36	9.62	0.26	2.70
8	2019	4076	19131	9.62	9.86	0.24	2.89
9	2020	3786	22917	9.86	10.04	0.18	3.84
10	2021	3945	26862	10.04	10.20	0.16	4.36
	Total	26862					

The relative growth rate (RGR) and the doubling time (Dt) were calculated and the result is present in table 2. From the study it is identified the table 2, the relative growth rate is 0.81 in the year 2013 and 0.16 in the year 2021. This study confirmed that the relative growth rate is decreasing trend. At the same time doubling time found that 0.85 in the year 2013 and 4.36 in the year 2021 and it confirmed that doubling time is an increasing trend during the study period.



## Document wise Distribution of Robotics Research Publications

**Table 3 Document wise Distribution of Robotics Research Publications**

S.No	Document type	Publications	%	Cumulative	%
1	Conference Paper	15680	58.37	15680	4.37
2	Article	8829	32.87	24509	6.83
3	Review	817	3.04	25326	7.05
4	Book Chapter	619	2.30	25945	7.23
5	Conference Review	505	1.88	26450	7.37
6	Book	141	0.52	26591	7.41
7	Editorial	122	0.45	26713	7.44
8	Note	68	0.25	26781	7.46
9	Short Survey	40	0.15	26821	7.47
10	Letter	15	0.06	26836	7.47
11	Erratum	10	0.04	26846	7.48
12	Data Paper	6	0.02	26852	7.48
13	Retracted	4	0.01	26856	7.48
14	Undefined	6	0.02	26862	7.48
	total	26862	100.00	359068	100.00

Table-3 demonstrated the document type wise distribution of publication for the study of robotics publications and it found that the conference papers were dominating over all the available conference paper with 15680(58.37%) records counted, followed by articles 8829(32.87%) and review with 817(3.04%), book chapter 619(2.30%), conference review with 505(1.88%), book with 141(0.525), editorial with 122(0.45%), note with 68(0.25), short survey with 40(0.15%) the minimum records were counted with letter 15(0.06%), erratum with 10(0.045), data paper 6(0.02%), retracted with 4(0.01%), undefined with 6(0.02%) record. The out of two document type conference paper, article are 91.24% and another document type 8.76% during the period of study

## Top 10 Subject - wise Robotics Distribution of Publications

**Table 4 top 10 Subject - wise Robotics Distribution of Publications**

S.No	Subject	Publications	%
1	Agricultural and Biological Sciences	387	1.72
2	Arts and Humanities	323	1.44
3	Biochemistry, Genetics and Molecular Biology	1197	5.33
4	Business, Management and Accounting	374	1.66
5	Chemical Engineering	572	2.55
6	Chemistry	611	2.72
7	Computer Science	17712	78.84
8	Decision Sciences	803	3.57
9	Dentistry	8	0.04
10	Earth and Planetary Sciences	478	2.13
	Total	22465	100.00

Table-4 the top 10 subjects wise distribution of publication during the period of study. It found that the maximum with 17712 (78.84%) research publications have been founded on Computer Science subject, followed by Biochemistry, Genetics and Molecular Biology subject with 11978(5.33%)research publications, and then Decision Sciences subjects with 803(3.57%) research publications and the subject with 10th rank minimum with 8 (0.04%)research publications was founded on Dentistry.

### Top 10 Author Robotics Research publications

**Table 5 top 10 Author Robotics Research publications**

S.No	Author	Country	Publications	%	Citations	%	CPP	H-Index	RCI
1	Ceccarelli, M.	United States	51	13.42	270	3.12	5.29	9	0.23
2	Guo, S.	China	49	12.89	501	5.78	10.22	13	0.45
3	Carbone, G.	Germany	38	10.00	176	2.03	4.63	8	0.20
4	Huang, Q.	United Kingdom	37	9.74	189	2.18	5.11	7	0.22
5	Wu, X.	Italy	37	9.74	317	3.66	8.57	9	0.38
6	Caldwell, D.G.	Japan	35	9.21	1062	12.25	30.34	15	1.33
7	Rus, D.	India	35	9.21	2844	32.82	81.26	22	3.56
8	Laschi, C.	Canada	33	8.68	2723	31.42	82.52	18	3.62
9	Ren, H.	France	33	8.68	564	6.51	17.09	15	0.75
10	Pransky, J.	South Korea	32	8.42	20	0.23	0.63	3	0.03
	Total		380	100.00	8666	100.00			

Table-5 provides the top 10 authors during the study period. Among these authors, it can be seen that the author Ceccarelli, M. the United States secure first position contributed 51(13.42%) research publications, while the author Guo, S. China secure second position contributed 49(12.89%) research publications. The author, Carbone, G. Germany with 38(10.00%), and with 10th rank contributed Pransky, J. South Korea with 32(8.42%) research publications during the study period. The highest citations with 2844(32.42%) Rus, D, India, the CPP is 81.26, h-index is 22, and RCI is 3.56, and the lowest citations with 20(0.23%) Pransky, J. South Korea, the CPP is 0.63, h-index is 3, and RCI is 0.03.

### Top 10 keywords Robotics Research publications

**Table 6 top 10 keywords Robotics Research publications**

S.No	Keyword	Publications	%
1	Robotics	15995	32.55
2	Machine Design	8747	17.80
3	Robots	7069	14.38
4	Human Robot Interaction	3099	6.31
5	Machine Learning	3059	6.22
6	Man Machine Systems	2749	5.59

7	Human	2287	4.65
8	Agricultural Robots	2101	4.28
9	Intelligent Robots	2020	4.11
10	Artificial Intelligence	2017	4.10
	Total	49143	100.00

Table-6 depicts the top 10 keywords which were used in robotics research publications. The maximum 15995(32.55%) research publications, the robotics keyword was used, followed by a robot keyword Machine Design with 8747(17.80%)research publications and the Robots with 7069(14.385), the minimum 2017(4.10%) research publications in aartificial intelligence the secure 10th rank during the study period.

### Top 10 Organization Robotics Research publications

**Table 7 top 10 Organization Robotics Research publications**

S.No	Organization	Publications	%	Citations	%	CPP	H-Index	RCI
1	Chinese Academy of Sciences	467	17.83	8960	16.64	19.19	43	0.93
2	Harbin Institute of Technology	314	11.99	1787	3.32	5.69	18	0.28
3	Ministry of Education China	260	9.93	3265	6.06	12.56	28	0.61
4	Massachusetts Institute of Technology	253	9.66	11661	21.66	46.09	47	2.24
5	Istituto Italiano di Tecnologia	234	8.93	4092	7.60	17.49	34	0.85
6	Georgia Institute of Technology	229	8.74	6308	11.71	27.55	37	1.34
7	Technical University of Munich	225	8.59	3684	6.84	16.37	29	0.80
8	CNRS Centre National de la Recherche Scientifique	214	8.17	3869	7.19	18.08	25	0.88
9	Carnegie Mellon University	212	8.09	6851	12.72	32.32	40	1.57
10	Tsinghua University	211	8.06	3371	6.26	15.98	23	0.78
	Total	2619	100.00	53848	100.00			

Table-7 shows the profile of the top 10 organization which was contributed to research publications during the period of study. The maximum 467(17.83%) research publications were contributed by the Chinese Academy of Sciences, followed by 314(11.99%) research publications contributed by Harbin Institute of Technology and 260(9.93%) research publications were contributed by Ministry of Education China, and Tsinghua University with 10th position 211 (8.06%) research publications contributed during the study. The highest citation with 11661(21.66%), the CPP is 46.09, h-index is 47, and 2.24, and the lowest citations with 1787(3.32%), the CPP is 5.69, h-index is 18, and RCI is 0.28.

### Top 10 Country Robotics Research Publications

**Table 8 top 10 Country Robotics Research Publications**

S.No	Country	Publications	%	Citations	%	CPP	H-Index	RCI
1	United States	5795	27.79	105474	38.37	18.20	133	1.38
2	China	4698	22.53	40855	14.86	8.70	78	0.66

3	Germany	1957	9.39	29562	10.75	15.11	66	1.15
4	United Kingdom	1735	8.32	23889	8.69	13.77	65	1.04
5	Italy	1532	7.35	22183	8.07	14.48	63	1.10
6	Japan	1361	6.53	12075	4.39	8.87	48	0.67
7	India	1327	6.36	6206	2.26	4.68	32	0.35
8	Canada	894	4.29	11882	4.32	13.29	51	1.01
9	France	796	3.82	10787	3.92	13.55	47	1.03
10	South Korea	755	3.62	11965	4.35	15.85	43	1.20
	Total	20850	100.00	274878	100.00			

Table-8 the top 10 Country in the world during the period of study. From the study that the United States was the maximum with 5795(27.79%) research publications and it is dominating over all the country which are contributed publication during the study, then followed by China with 4698(22.53%) research publications and Germany was research publications with 1957(9.39%), the South Korea is 10th ranking with 755(3.62%) research publications. The highest citations with 105474(38.37%), CPP is 18.20, h-index is 133, and RCI is 1.38, the lowest citations with 6206(2.26%), the CPP is 4.68, h-index is 32, and RCI is 0.35.

### Top 10 Journals Robotics Research publications

#### Tale 9 top 10 Journals Robotics Research publications

S.No	Journals	Publications	%	Citations	%	CPP	H-Index	RCI
1	Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics	1048	22.24	4196	11.66	4.00	24	0.52
2	ACM IEEE International Conference On Human Robot Interaction	661	14.03	5441	15.12	8.23	35	1.08
3	Advances In Intelligent Systems And Computing	589	12.50	1334	3.71	2.26	12	0.30
4	Proceedings IEEE International Conference On Robotics And Automation	581	12.33	11764	32.70	20.25	51	2.65
5	ACM International Conference Proceeding Series	394	8.36	516	1.43	1.31	8	0.17
6	IEEE International Conference On Intelligent Robots And Systems	368	7.81	4296	11.94	11.67	29	1.53
7	IEEE Robotics And Automation Letters	311	6.60	4439	12.34	14.27	32	1.87
8	Mechanisms And Machine Science	278	5.90	790	2.20	2.84	11	0.37
9	Applied Mechanics And Materials	270	5.73	289	0.80	1.07	8	0.14
10	IEEE Access	212	4.50	2915	8.10	13.75	27	1.80
	Total	4712	100.00	35980	100.00			

Table- 9 depicts the top 10 major Journals which were used in robotics research publications. The maximum 1048(22.24%) research publications robotics Journals in Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In

Bioinformatics, followed by a ACM IEEE International Conference On Human Robot Interaction with 661(14.03%) research publications, Advances In Intelligent Systems And Computing with the 589(12.50%) research publications, the minimum 212(4.50%) research publications in IEEE Access and secure 10th rank during the study period. The highest citations with 11764(32.70%) research publications in Proceedings IEEE International Conference on Robotics and Automation, CPP is 20.25, h-index is 51, and RCI is 2.65, the lowest citations with 289(0.80%) Applied Mechanics and Materials, CPP is 1.07, h-index is 8, and RCI is 1.80.

### Top 10 Funding Agency Robotics Research Publications

**Table 10 top 10 Funding Agency Robotics Research Publications**

S.No	Funding	Publications	%
1	National Natural Science Foundation of China	1736	29.89
2	National Science Foundation	1118	19.25
3	European Commission	665	11.45
4	Horizon 2020 Framework Programme	551	9.49
5	Engineering and Physical Sciences Research Council	339	5.84
6	Seventh Framework Programme	317	5.46
7	Japan Society for the Promotion of Science	306	5.27
8	National Key Research and Development Program of China	273	4.70
9	Fundamental Research Funds for the Central Universities	257	4.43
10	National Institutes of Health	245	4.22
	Total	5807	100.00

Table- 10 depicts the top 10 major funding agency which were used in robotics research publications. The maximum funding agency with 1736(29.89%) research publications National Natural Science Foundation of China, followed by a funding agency National Science Foundation with 1118(19.25%) research publications and European Commission funding agency with the 665(11.45%) research publications the minimum of funding agency with 245(4.22%) research publications in National Institutes of Health during the study period.

### Top 10 Language Robotics Research Publications

**Table 11 top 10 Language Robotics Research Publications**

S.No	Language	Publications	%
1	English	26332	97.95
2	Chinese	308	1.15
3	Spanish	53	0.20
4	German	52	0.19
5	Russian	39	0.15
6	Korean	27	0.10
7	French	23	0.09
8	Turkish	21	0.08
9	Japanese	17	0.06
10	Italian	12	0.04
		26884	100.00

Table- 11 depicts the top 10 major language which were used in robotics research publications. The maximum 26332(97.95) research publications in robotics English language was used, followed by a robot Chinese language with 308(1.15%) research publications, and Spanish language with 53(0.20%) research publications, and the minimum 12(0.04%) research publications procedures Italian language was used and secure 10th rank during the study period.

### Time Series Analysis in Research Publications

**Table 12 Time Series Analysis in Research Publications**

S.No	Years	Count(Y)	X	Y2	XY
1	2012	1245	-5	25	-6225
2	2013	1560	-4	16	-6240
3	2014	1745	-3	9	-5235
4	2015	2102	-2	4	-4204
5	2016	2238	-1	1	-2238
6	2017	2756	1	1	2756
7	2018	3409	2	4	6818
8	2019	4076	3	9	12228
9	2020	3786	4	16	15144
10	2021	3945	5	25	19725
	Total	26862		110	32529

Table-12 time series analysis study reveals that, the estimated growth values are identified based on previous data. A straight –line equation is adapted to measure the future values based on previous data. Time series analysis used by **Jeysankar and Ramesh babu (2013)**<sup>25</sup>.

This study identified the future prediction of Robotics research publications in India for the year 2025 and 2030.

Straight Line Equation is

$$Y = a + bx$$

Here,

$$\sum Y = 26862, \sum X^2 = 110, \sum XY = 32529$$

$$a = \sum Y / N = 26862 / 10 = 2686.2 = 2686$$

$$b = \sum XY / \sum X^2 = 32529 / 110 = 295.71 = 296$$

Estimate growth of publications in the year 2025 is, when  $x = 2025 - 2015 = 10$

$$Y = a + bx$$

$$= 2686 + (110 * 10) = 2686 + 1100 = 3786$$



Estimated growth of publications in the year 2030 is, when  $x = 2030 - 2015 = 15$

$$Y = a + bx$$

$$= 2686 + (110 \times 15) = 2686 + 1650 = 4336$$

The robotic research publications in India in the year 2025 is around are equal to 3786 publication and the year 2030 is around are equal to 4336 publications. The statistical application analysis of the time series analysis is estimated growth based. So that the time serious analysis study conformed robotics research publications is increasing trend.

### Top 10 Highly Cited Paper in Research Publications

**Table -13 top 10 Highly Cited Paper in Research Publications**

S.No	Titles of Highly cited papers	Citations	Document types
1	Amjadi, M., (2016) Stretchable, Skin-Mountable, and Wearable Strain Sensors and Their Potential Applications: A Review, <i>Advanced Functional Materials</i> , 26(11):1678-1698.	1623	Review
2	Hochberg, L.R., (2012) Reach and grasp by people with tetraplegia using a neurally controlled robotic arm, 485(7398):372-375.	1547	Article
3	Sze, V., (2017) Efficient Processing of Deep Neural Networks: A Tutorial and Survey, <i>Proceedings of the IEEE</i> , 105(12):2295-2329.	1297	Review
4	Huang, G., (2015) Trends in extreme learning machines: A review, <i>Neural Networks</i> , 61: 32-48.	1180	Review
5	Kim, S., (2013) Soft robotics: A bioinspired evolution in robotics, <i>Trends in Biotechnology</i> , 31(5):287-294.	1126	Review
6	Davies, M., (2018) Loihi: A Neuromorphic Manycore Processor with On-Chip Learning, <i>IEEE Micro</i> , 38(1):82-99.	983	Article
7	Wang, S., (2018) Skin electronics from scalable fabrication of an intrinsically stretchable transistor array, <i>Nature</i> , 555(7694):83-88.	981	Article
8	Beard, R.W., and McLain, T.W. (2012) Small unmanned aircraft: Theory and practice, <i>Small Unmanned Aircraft: Theory and Practice</i> , 300.	848	Book
9	Mosadegh, B., (2014) Pneumatic networks for soft robotics that actuate rapidly, <i>Advanced Functional Materials</i> , 24(15):2163-2170.	809	Article
10	Hu, W., (2018) Small-scale soft-bodied robot with multimodal locomotion, <i>Nature</i> , 554(7690):81-85.	776	Article

Table- 13 the highest cited paper 1623 of Amjadi, M., (2016) Stretchable, Skin-Mountable, and Wearable Strain Sensors and Their Potential Applications: A Review, *Advanced Functional Materials*, 26(11):1678-1698. The Second highly cited paper 1547 of Hochberg, L.R., (2012) Reach and grasp by people with tetraplegia using a neurally controlled robotic arm, 485(7398):372-375. Third highly cited paper 1297 of Sze, V., (2017) Efficient Processing of Deep Neural Networks: A Tutorial and Survey, *Proceedings of the IEEE*, 105(12):2295-2329. The total document type 05 article, 04 review, 01 book during the studt period.

## Major Finding

- The present study aims to analysis the research productivity trend on the title “Robotics” research publications worldwide during 2012-2021 on the base of the Scopus database. A total of 26862 research publications, and it found that the maximum 4076 (74.46%) articles were published in the year 2019, followed by the year 2021 with 3945(72.07%) articles, and the 3786(69.16%) articles were published in the year 2020 during the study period.
- During the study period the highest citation with 42249(15.47%), and cited with 424(10.03%), uncited with 2985(13.19%). The h-index is 84, CPP is 12.39, and RCI is 0.25 in the years, and the lowest citation with 6275 (2.30%), cited with 331(7.83%), uncited with 3614(15.97%), h-index is 23, CPP is 5.21, and RCI is 0.03. The compound annual growth ratio is 12.22.
- The study a maximum RGR 0.81 has been recorded in the year 2013 and minimum RGR 0.16 has been counted in the year 2021 in the order of decreasing trend, while the maximum doubling time 4.36 has been counted in the year 2021 and the minimum doubling time 0.85 has been counted in the year 2013 in the order of increasing trend.
- The study conference paper with 15680(58.37%) records counted, followed by articles 8829(32.87%) and review with 817(3.04%), book chapter 619(2.30%), conference review with 505(1.88%), and the maximum 17712 (78.84%) articles have been founded on Computer Science subject, followed by Biochemistry, Genetics and Molecular Biology subject 11978(5.33%), Decision Sciences subjects with 803(3.57%) articles.
- During the author Ceccarelli, M. the United States secure first position contributed 51(13.42%) articles, while the author Guo, S. China secure second position contributed 49(12.89%) articles. The author, Carbone, G. Germany with 38(10.00%), the highest citations with 2844(32.42%) Rus, D, India, the CPP is 81.26, h-index is 22, and RCI is 3.56.
- During the maximum institutions with 467(17.83%) articles were contributed by the Chinese Academy of Sciences, followed by 314(11.99%) articles contributed by Harbin Institute of Technology and 260(9.93%) articles were contributed by Ministry of Education China, The highest citation with 11661(21.66%), the CPP is 46.09, h-index is 47, and 2.24.
- During the United States was secured 1st rank with 5795(27.79%) articles and it is dominating over all the country which are contributed articles during the study, then China was the 2nd rank holder of the study with 4698(22.53%) articles and Germany was the 3rd rank holder with 1957(9.39%) articles, The highest citations with 105474(38.37%), CPP is 18.20, h-index is 133, and RCI is 1.38.
- The study a maximum 1048(22.24%) times robotics Journals in Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics, followed by a ACM IEEE International Conference On Human Robot

Interaction with 661(14.03%), Advances In Intelligent Systems And Computing with the 589(12.50%), The highest citations with 11764(32.70%) Proceedings IEEE International Conference on Robotics and Automation, CPP is 20.25, h-index is 51, and RCI is 2.65.

- The study a maximum funding agency with 1736(29.89%) National Natural Science Foundation of China, followed by a funding agency National Science Foundation with 1118(19.25%) and European Commission funding agency with the 665(11.45%) during the study period, and The study the maximum 15995(32.55%) robotics keyword was used, followed by Machine Design with 8747(17.80%) times and the Robots with 7069(14.385).
- During the time series analysis statistical application will be expected in the Leukemia research publications in the year 2025 is around are equal to 3786 publications and the year 2030 is around are equal to 4336 publications in increasing trend.
- The highest cited paper of 1623 Amjadi, M., (2016) Stretchable, Skin-Mountable, and Wearable Strain Sensors and Their Potential Applications: A Review, *Advanced Functional Materials*, 26(11):1678-1698. Second highly cited paper of 1547 Hochberg, L.R., (2012) Reach and grasp by people with tetraplegia using a neurally controlled robotic arm, 485(7398):372-375.

## Reference

1. **Saha S.K**, Introduction to Robotics, McGraw Hill Education (India) private limited publications, New Delhi, 2008, 1-2.
2. **Bruno Siciliano et.al**, Robotics: Modelling planning & control, Springer- Verlag London Limited, 2010, 1-2.
3. **Cole E J and Eales, NB, (1917)**. The history of comparative anatomy: A statistic a analysis of the literature, *Science Progress*, 11(44): 578-963.
4. **Hulme EW (1923)** Statistical bibliography in relation to the growth of modern civilization, London: Grafton, 112, 585–586.
5. **Ranganathan S R (1995)** Library and its scope Bangalore DRTC Seventh seminar volume paper DA, *International journal of scientometrics and info metrics*, 1(1): 15-21.
6. **Prichard A, (1969)** Statistical Bibliography of Bibliographies, *journal of documentation*, 25(4) (1969) 348-349.
7. **Van Raan A F J (1997)** Scientometrics state- of The Art, *Scientometrics*, 38(1):205-218.
8. **Sab, M. C., Kumar, P. D., and Biradar, B. S. (2018)**. Growth of literature and measures of scientific productivity of Indian Chemical Science research during 2002-2016. *Journal of Advanced Chemical Sciences*, 04(01), 525–530.
9. **Gupta, B.M., Dhawan, S.M. and Gupta, R. (2017)**. World Mobile Research : A Scientometric Assessment of Research Publications Output during 2007-16. *Library Philosophy and Practice (e-journal)*
10. **Dhawan, S. M., Gupta, B. M., & Gupta, R. (2016)**. Research in electronic publishing field: A scientometric assessment of publications output during 2005-14. *Annals of Library and Information Studies*, 63(1), 59–67.

11. **Santhakumar, R., and Kaliyaperumal, K. (2014).** Mapping of mobile technology publications: A scientometric approach. *DESIDOC Journal of Library and Information Technology*, 34(4), 298–303.
12. **Kumar, K. (2014).** A Scientometric Study of Digital Literacy in Online Library Information Science and Technology Abstracts (LISTA). *Library Philosophy and Practice (e-journal)*.
13. **Ajay Kumar (2021)** Research trend on Robotics during 2009-2018: A scientometric analysis based on Scopus database, *Library Philosophy, and Practice (e-journal)*, 4312, 1-10.
14. **Gaud Nutan (2019)** A Critical Analysis of Scientific Productivity of the Robotics Research in India during 2009-2018, *Library Philosophy and Practice (e-journal)*, 2345, 1-14.
15. **Ravichandran, and Vivekanandhan (2022)** Scientometric analysis of diabetics research output from the Scopus database during 1971-2020 in India, *International Journal of Development Research*, 12(04): 55074-55080.
16. **Ravichandran and Siva (2022)** Infertility research output in India from the Scopus database during 2012-2021: a scientometric analysis, *International journal of arts and science research*. 9(1): 194-209.
17. **Ashokkumar, L. and Gopalakrishnan, S. (2013).** Indian literature output on Textile Research: A Scientometric Study. *Journal of Advances in Library and Information Science*, 2(4), 251-258.
18. **Bharvi, D. and Khaiser, N. (2016).** Scientometric analysis of global solar cell research. *Annals of Library and Information Studies*, 63, 31-41.
19. **Hirsch, J.E.** An index to quantify an individual's scientific research output. *Proceedings of the National Academy of Sciences*, 102(46), 2005, 16569-16572.
20. **Ye, F.Y.** An investigation of mathematical models of the h-index. *Scientometrics*, 81(2), 2009, 493-98.
21. **Schubert, A. and Glanzel, W.** A systematic analysis of Hirsch-type indices for journals. *Journal of Informetrics*, 1(2), 2007, 179-184.
22. **Egghe, L. and Rousseau, R.** An informatics model for the Hirsch index. *Scientometrics*,; 69(1), 2003, 121-129.
23. **Gupta, B.M. and Bala, A.** Epilepsy Research in India: A Scientometric Analysis of Publications Output during 2002-11. *Annals of Neurosciences*, 20(2), 2013, 71-78.
24. **Mahapatra, M. (1985).** On the validity of the theory of exponential growth of scientific literature. In *15th IASLIC conference proceedings*, Bangalore, 61-70.
25. **Jeyashankar R, Ramesh Babu B. (2013).** Scientometric Analysis of Leukemia Research output 1960-2011: An Indian perspective. *Asia pacific Journal of Library and information science*, 3(2), 1-15