



Contribution ID: 68

Type: Sectional reports

Mechanisms for identifying the patterns of the dynamics of scientific and technical publications on the example of the thematic direction "Robotics"

Tuesday, 6 July 2021 13:45 (15 minutes)

Introduction

In world practice, the number of published articles in leading scientific publications is indicators of the results of scientific activities of researchers, research organizations and higher educational institutions. International publication activity reflects the level of development of national science against the background of other countries, especially in the field of basic research, where there can be no results other than publications by definition. In developed countries, to track and analyze the dynamics of scientific information flows, information and analytical systems have been developed that aggregate scientific publications. Currently, the most famous systems of this type are Web of Science (WoS) and Scopus.

Web of Science is a collection of diverse databases collected on the ISI Web of Knowledge platform and processed by the US Institute of Scientific Information. WoS provides researchers and professionals with information on all branches of knowledge among more than 12 000 journals and 120 000 conference materials, more than 4 400 sites. Access to the bases WoS licensed and is provided on a paid basis to universities, institutes, scientific organizations and individuals. Subscription payment allows you to access full-text versions of materials and perform various types of searches on the database. WoS includes three interrelated databases: Science Citation Index Expanded; Social Sciences Citation Index; Arts and Humanities Citation Index. The platform has built-in capabilities for searching, analyzing and managing bibliographic information. The depth of the Web of Science archive has been since 1970.

Scopus is a system of bibliographic databases related to various fields of science. Scopus is owned and operated by Elsevier, a Dutch publishing company. Scopus indexes more than 20 thousand scientific publications on technical, medical and humanities, owned by 5 thousand publishers. Scopus also indexes conference materials and serial book publications. As of early 2010, Scopus includes over 38 million scientific publication records, including over 19 million resource records published since 1996 with cited bibliography lists. The Scopus database is available as a paid subscription via a web interface and consists of four basic subject areas: Life Sciences, Health Sciences, Physical Sciences, Social Sciences & Humanities.

Both databases are widely used in many countries of the world to assess the effectiveness of both individual researchers and scientific teams and institutions. Thus, using the built-in tools of information and analytical systems, it is possible to analyze the publication activity in any area of research of interest.

1. Rationale for selecting a study topic

The idea of creating a mechanical device similar to humans or other living beings, both in appearance and in actions, has been an area of interest for humanity since time immemorial. The main motive for this interest was the desire to facilitate human labor, simplify the study of the surrounding world and provide protection from the enemy. In connection with the development of technological knowledge of society and the complexity of production, the emergence and development of a variety of controlled machines inevitably led to the formation of a new scientific direction –robotics. Robotics is an applied science based on cybernetics, bionics and mechanics, engaged in the development of automated technical systems based on electronics and programming. Robotics studies both the theory, methods of calculating and designing robots, their systems and elements, and the problems of complex automation of production and scientific research using robots.

When creating the first robots up to the present day, human capabilities serve as a model for them. It was the desire to replace a person in hard and dangerous work that gave rise to the idea of creating a robot. Robots owe their advent, in particular, to computerization of production, automation of technological processes, as

well as the vast experience gained in the operation of machining machines with numerical program control. The choice of robotics, as the subject of this study, is not accidental, because it is a promising, high-tech, dynamically developing sphere that is located at the junction of related industries. Many of the world's leading powers are engaged in research and development in this field. The scope of robotics is quite extensive. These can be simple robots that execute simple commands, and there can be complex robots that execute a whole set of algorithms. Each robot or program consists of a huge number of components, and this requires a certain precision in the development and high qualifications and competence of the developers of robotic systems. In addition, in the area under consideration there are many involved objects that participate in the creation of robots. And finally, there is a huge variety of information about the robotic field, which allows you to systematize the accumulated experience and analyze trends of interest.

2. Express analysis of the thematic area "Robotics"

The present study to assess the cyclicity of publications was conducted on the basis of the Web of Science search platform. To analyze publication activity in the WoS system, the following search query ("extended search") was compiled "by category WoS" - WC: "WC = Robotics" with a filter by year "1970-2019."

The search results page presents 168,562 publications and conference materials as of the second quarter of 2019. The first publication in the «Robotics» category appeared in the Web of Science archive in 1989. This year can be considered the beginning of serious publication activity in this area.

We will analyze the current state of development of this area based on data that can be obtained from the abstract database WoS. Figure 1 shows a graph of the total number of publications on a given topic from 1995 to 2018.

Figure 1. The number of publications on the topic "Robotics" from 1995 to 2018

Green indicates the years when there is an increasing interest in robotics. The decline in publication activity and the stationary use of technologies are shown in orange. Years of maximum publication activity are highlighted in red. As you can see, from 1989 to 1999, the world community conducted some research and conferences, published articles, but the jump in the development of interest in robotics and the beginning of active publication activities in the world occurred in 1999-2000, and amounted to almost 2 500 publications. In the period from 2000 to 2008 there was a continuous growth, the latest solutions in technology were introduced. Growth peaked in 2008 at 11 418 publications. Further, from 2009 to 2011, some developments were made on the basis of published documents and from 2011 to 2015 there was a new jump in interest and, accordingly, the development of robotics, the number of publications reached almost 7 000. After the peak of growth, as in 2008, publication activity began to decline, which means that since 2015 active development of "tried-and-tested" technologies has been underway.

Figure 2 is a diagram of the relationship of document types published in the archive WoS. The largest number of documents published are conference materials and articles: 127 016 documents and 38 437 documents, respectively. Consider these directions separately below.

Figure 2. The ratio of the number of all publications on the topic "Robotics"

Figure 3 shows the distribution of the number of documents by country. As you can see in the chart, the United States of America is the leader in the total number of published documents (30 971 documents). They are followed by the People's Republic of China (27 624) and Japan (20 783). It can be concluded that the study of the topic of "Robotics" is most actively engaged in these three countries.

Figure 3. Distribution of publications by country

2.1. Research of conference materials on the topic "Robotics"

Let's analyze the current state of documents on thematic conferences based on the data from the WoS abstract database. To do this, we investigate the publication activity by the authors of thematic conferences from 1989 to 2019. Figure 4 presents data on the number of worldwide publications for the specified period.

From 1989 to March 2019, 127,016 documents of this type were published. According to the diagrams in Figure 4, it can be seen that interest in robotics in the world was manifested in 2000, when the number of publications increased from 95 to 2691. The largest number of documents published after thematic conferences (13 274) is in 2015 year. The smallest number of works (9) is in 1989 and 1991.

Figure 4. Publications in thematic conferences in 1989-2018

In total, 3 725 conferences were held in the direction of Robotics. Table 1 shows the names of robotic conferences and the number of publications (according to the principle of more than 700 published documents) based on the results of the conferences held during the entire existence of the section of interest to us in WoS.

Table 1. Conferences and the number of publications following them

№ Conference name Number of documents

1 IEEE RSJ INTERNATIONAL CONFERENCE ON

INTELLIGENT ROBOTS AND SYSTEMS IROS 10745

2 IEEE INTERNATIONAL CONFERENCE ON ROBOTICS AND AUTOMATION ICRA 8531

3 IEEE INTERNATIONAL CONFERENCE ON ROBOTICS AND AUTOMATION 3833

4 IEEE INTERNATIONAL CONFERENCE ON ROBOTICS AND

BIOMIMETICS ROBIO 2121
 5 IEEE INTERNATIONAL CONFERENCE ON
 MECHATRONICS AND AUTOMATION 2072
 6 25TH IEEE RSJ INTERNATIONAL CONFERENCE ON
 INTELLIGENT ROBOTS AND SYSTEMS IROS 1938
 7 7TH WORLD CONGRESS ON INTELLIGENT CONTROL AND
 AUTOMATION 1831
 8 SICE ICASE INTERNATIONAL JOINT CONFERENCE 1237
 9 INTERNATIONAL CONFERENCE ON CONTROL
 AUTOMATION AND SYSTEMS 1116
 10 IEEE INTERNATIONAL CONFERENCE ON SYSTEMS MAN
 AND CYBERNETICS 1095
 11 IEEE ASME INTERNATIONAL CONFERENCE ON
 ADVANCED INTELLIGENT MECHATRONICS AIM 976
 12 39TH IEEE CONFERENCE ON DECISION AND CONTROL 955
 13 IEEE INTERNATIONAL SYMPOSIUM ON INDUSTRIAL
 ELECTRONICS 912
 14 IEEE ASME INTERNATIONAL CONFERENCE ON
 ADVANCED INTELLIGENT MECHATRONICS 908
 15 AMERICAN CONTROL CONFERENCE ACC 903
 16 IEEE INTERNATIONAL CONFERENCE ON SYSTEMS MAN
 AND CYBERNETICS SMC 03 821
 17 INTERNATIONAL CONFERENCE ON ARTIFICIAL LIFE
 AND ROBOTICS ICAROB 817
 18 7TH INTERNATIONAL CONFERENCE ON MACHINE
 LEARNING AND CYBERNETICS 750
 19 20TH IEEE INTERNATIONAL CONFERENCE ON ROBOTICS
 AND AUTOMATION ICRA 730
 20 19TH IEEE INTERNATIONAL CONFERENCE ON ROBOTICS
 AND AUTOMATION ICRA 722

The leading conferences, at the end of which the largest number of documents are published, are conferences supported by the international non-profit association of specialists in the field of engineering, the Institute of Electrical and Electronics Engineers (IEEE). For convenience and clarity, such conferences have been highlighted in green.

2.2. Research of published articles on the subject of "Robotics"

Let's analyze the current state of publication of articles on the subject of "Robotics" based on data from the WoS abstract database from 1983 to 2018 (Figure 5). A total of 38 448 documents of this type were published during this period. Based on the data obtained, we can conclude that interest in the topic of "Robotics" is growing from year to year, which is confirmed by the steady increase in the number of published articles. Interestingly, conferences on topics of interest began to be held in 1989 and, accordingly, documents on the results of conferences began to appear at the same time. Articles on the chosen topic began to be published six years earlier, in 1983. The jump in more than 800 published documents is also observed in 2015.

Figure 5. The number of published articles on the subject of "Robotics" from 1983 to 2018

3. Development of related areas

The development of robotics is largely determined by the level of development of related industries: the science of materials, as well as the development of computer technology. Data on the conducted interdisciplinary research are presented in Table 2.

Table 2. Number of publications in related industries

№ Categories Web of Science Количество публикаций

- 1 Computer Science, Artificial Intelligence 75 015
- 2 Automated control systems 69 038
- 3 Electrical and Electronic Engineering 52 247
- 4 Computer Science, Cybernetics 13 171
- 5 Computer Science, Theory and Methods 11 224
- 6 Mechanical engineering 10 327
- 7 Computer science, information systems 9 348
- 8 Компьютерные науки, междисциплинарные применения 7 985

Based on the data of Table 2, it can be concluded that for the entire time that the Robotics topic exists in the WoS, the largest number of documents affect such related topics as Computer Science, Artificial Intelligence (more than 44%), Automated Control Systems (more than 41%) and Electrical and Electronic Engineering (more than 31%). From 2009 to 2018, three blocks of headings can be distinguished:

1. Sustainable development.
2. Forward-looking studies.
3. Bursts.

The sustainable development block is characterized by positive publication dynamics. The leading topics are: computer science, artificial intelligence (43 180 publications), automated control systems (31 781 publications), electrical and electronic engineering (29 514 publications).

The block of perspective studies is represented by 20 areas that have a positive dynamics of publications in the period under consideration. The topics of the use of robotics in the social sphere are touched upon - medicine, education.

The burst block is represented by a single increase in publications, so far it is impossible to assess the development of such interdisciplinary studies. In addition, it was revealed that 43 thematic headings are found once, which indicates the conduct of interdisciplinary studies in these areas.

In addition to the leading topics (1 300 published documents over 10 years), some areas were selected that are inherently associated with robotics. From the diagram (Figure 6) it can be seen that the jump in the publication of documents precisely on the study of artificial intelligence occurred in 2015. Studies on automation of systems management show a stable number of documents - about 3 000 per year. With regard to electrical and electronic engineering, approximately 2 500 papers are published annually. Figure 6 also shows the distribution for 6 main headings out of 71 presented. It is in the six areas indicated below that the largest number of documents are published.

Figure 6. Number of publications on related topics from 2009 to 2018

Conclusions

In the world, a steady rapid increase in scientific activity was indicated in the 2000s. Leading positions are occupied by the USA, Japan, China.

The development of scientific thought does not occur progressively, but, rather, cyclically. Time is needed for research, development of presented concepts and new results. Such a period can reach 5-7 years, after which a sharp jump in publication activity is visible, then it goes on a decline. More progressive technologies are emerging, scientific thought is developing in accordance with the various needs of time. Past developments are being supplanted and replaced by more efficient next-generation technologies. After about 5-7 years, the situation repeats again.

The thematic area "Robotics" is developing intensively, this is evidenced by the active publication activities of leading countries and countries interested in the development and use of robotics. Interest in this area is growing. Due to the fact that robotics is at the junction of industries, such related areas as artificial intelligence, automated control systems, electrical and electronic engineering, and materials science are actively developing in parallel. Therefore, the further development of robotics will largely be determined, including by the development of related areas.

Acknowledgements

The study was carried out at the expense of the Russian Science Foundation grant (project # 19-71-30008).

Summary

Scientific activity is a source of new knowledge and the creation of the latest technologies to improve the quality of life. The results of research are presented in the form of articles published in scientific journals or collections of scientific conferences, thereby being the main channel of communication in the scientific environment, and also characterize the state of the scientific organization and the country in the world scientific ranking. The article analyzes the world publication activity of countries on the example of the direction - "Robotics" based on the data of the Web of Science system. It was revealed that the development of technologies is subject to certain laws and it is possible to build predicative models for the emergence of new techno

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Session Classification: Big data Analytics and Machine learning.

Track Classification: 9. Big data Analytics and Machine learning