The development of artificial intelligence: a bibliometric analysis, 2007-2016

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Abstract. The aim of this study is to research the development of artificial intelligence in bibliometrics perspective. Bibliometrics, as one sub-field of scientometric, is an effective tool to evaluating research trends in different fields. The total number of 1188 publications between 1st January 2007 to 31, December 2016 was identified from an academic database Web of Science. In this study, yearly research output, distribution of publication by countries, most productive publication institutions, most productive authors, distribution of research field, artificial intelligence-related researches were analyzed based on bibliometrics. This study tries to provide a valuable reference for researchers to understand the development of artificial intelligence in multiple perspectives.

1. Introduction
The era of artificial intelligence has begun, and artificial intelligence has been applied extensively in a lot of professions. Artificial intelligence (AI) techniques are becoming useful as alternate approaches to conventional techniques or as components of integrated systems. They have been used to solve complicated practical problems in various areas and are becoming more popular nowadays [1]. Artificial intelligence has made great strides in many fields, such as sensors, machine learning and radios [2-4]. With the development of Internet and computing technology, the development of artificial intelligence will have great potential in the coming years [5,6]. Artificial intelligence has played an irreplaceable role in many fields over the past 20 years. Application of artificial intelligence had achieved good results in the utilization and allocation of natural resources, natural environment governance and protection [7-9]. Predictably, artificial intelligence will lead development of human in the future.

Bibliometrics is statistical analysis to evaluate the relative importance of scientific production in a specific field. It can effectively reflect the temporal evolution of research on a specific topic [10]. It can be applied to assess the scientific outputs of authors, countries, languages, research fields, institutions and cooperative relationship [11,12]. Bibliometrics have been widely used in computer science, library and information science, agronomy and other fields [13,14].

This study tries to present a comprehensive overview of artificial intelligence in the perspective of bibliometrics. The goals of this study are: (1) identifying yearly research output, type of publications and hot research topics in artificial intelligence; (2) evaluating authors, countries and institutions in different perspectives; (3) analyzing most frequently cited articles and obtaining the research trends, which maybe have certain reference value for researchers.
2. Materials and methods

2.1. Data source
In our research, a systematic review was conducted based on the academic database Web of Science. The data source in our study was obtained from Web of Science. We initially searched for the articles with the keyword “artificial intelligence” in the title; and then, we limited the publication time from 1st January 2007 to 31, December 2016. The articles with anonymous authors and the call for paper information were deleted from the data source.

2.2. Formatting author names
The records of 1188 articles were identified in our study with the help of specialized software. The above articles are analyzed according to the following aspects: (1) yearly research outputs; (2) distribution of publication by countries; (3) most productive publication institutions; (4) most productive authors; (5) distribution of research areas; (6) most frequently cited articles.

3. Results and analysis
In our study, we used the bibliometric analysis to analyze the published articles with the keyword “artificial intelligence”. The number of 1188 articles was identified from 1st January 2007 to 31, December 2016. The analysis results can be shown in the form of graphs and tables.

3.1. Yearly research outputs
The number of 1188 articles was identified in the academic database Web of Science from 2007 to 2016 (10 years). Results of yearly research output are shown in Figure 1. The number of published articles increased from 72 in the year of 2007 to 188 in the year of 2016. It can be seen from Figure 1 that the number of published articles increased steadily from 2007 to 2013, after the year of 2013, however, the published articles increased quickly, while compared with 2014, the number of published articles in 2015 declined, but the number remained high level. Results show that artificial intelligence has attracted serious concerns and more and more articles are published in recent 3 years. It can be predicted that with the development of application, artificial intelligence will be continuous hot in the next few years.

![Figure 1. The results of yearly research output](image)

3.2. Distribution of publication by countries
In the period of 2007 to 2016, among 1188 articles with author information, a total number of 62 countries are involved in our research. Part of articles was written by several authors with different nationalities. In such situation, these articles simultaneously belonged to different countries. United
States ranked the first place with the highest number of published articles (238, 20.03%), UK (124, 10.44%) ranked second, Iran (119, 10.02%) ranked third, Spain (92, 7.74%) ranked fourth, People Republic of China (72, 6.06%) ranked fifth, followed by Italy (58, 2.36%), India (58, 2.36%), Turkey (50, 4.21%), Canada (47, 3.96%) and France (46, 3.87%). The top 10 productive countries are shown in the Figure 2. Results reveal that United States leads the research and the number of published articles of these 10 countries increased year after year. Out of these 69 countries, 28 countries lie in Europe (45.16%), 17 in Asia (27.42%), 7 in Africa (11.29%), 5 in South America (8.06%), 3 in North America (4.84%), 2 in Oceania (3.23%). The results show that Europe and Asia lead the artificial intelligence-related research, which will be popular in the above continents in the near future.

3.3. Most productive publication institutions
During the period of 2007-2016, the 1352 institutions have involved in the 1188 publications. The analysis of institution distribution can help us understand the research capacities and activities around the world. The top 10 productive institutions with the number of publications are shown in Figure 3. These 10 institutions totally published 169 with the proportion of 14.23%, in which 7 in Asia countries and the other three in European and American countries. Islamic Azad University is top ranked with the publication number of 37. Results show that the high education institutions play an important role in this research.

3.4. Most productive authors
The top 10 productive authors based on publication number are shown in the Figure 4. Kisi, O. is the most productive author with 12 articles. It can be seen from Figure 4 that the publication number of all the top 10 authors are no less than 10, and Kisi, O. has great impact on the research.
3.5. Distribution of research fields

During the past 10 years, 1188 articles included 102 research fields. Figure 5 shows the top 10 research fields with publication numbers. Results show that artificial intelligence is involved a great amount of research fields, such as computer science artificial intelligence, engineering electrical electronic, engineering civil, engineering multidisciplinary, computer science interdisciplinary applications, energy fuels, multidisciplinary sciences, water resources and engineering chemical. It can be predicted that artificial intelligence will be a hotspot in the future.

3.6. Artificial intelligence-related researches

During the period of 2007-2016, artificial intelligence related researches include neural network, genetic algorithm, fuzzy logic, optimization, support vector machine, machine learning, anfis, modeling and prediction, as shown in Figure 8. These researches can be concluded the following three aspects: (1) research fields, such as neural network, machine learning; (2) technical methods, such as anfis, support vector machine, genetic algorithm, fuzzy logic, modeling; (3) thesauruses, such as optimization, prediction.
4. Conclusions

New technologies in information science have greatly changed our lives. One of the most popular technologies is artificial intelligence. As a new technological science, artificial intelligence mainly focuses on making computers simulate certain thinking processes and behaviors of people. Artificial intelligence articles have been published in recent 10 years. Our research is based on the research of artificial intelligence in Web of Science from 2007 to 2016. Some valuable conclusions can be drawn from our research: (1) Artificial intelligence has become more and more hot in a range of fields. Consequently, artificial intelligence related researches have increased significantly in the past 20 years. It's no doubt that the number of articles in this field will increase in future. (2) Artificial intelligence is involved a great amount of research fields, especially computer science and engineering. This trend is hard to change in a short time. (3) United States ranked the first place with the highest number of published articles, accounted for 20.03% of total world production. It can be predicted that its predominant position will be further enhanced in next few years. (4) The research hot spot of artificial intelligence researches mainly focuses on machine learning. Its research scopes maybe expanded in future.

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