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International Cooperation Among Artificial Intelligence Research Teams Based on Regional Cooperation Models

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Abstract: The paper explores the regional cooperation model and the differences among artificial intelligence research teams. It is helpful to reveal the status and strategies of scientific cooperation models across regions or within regions. We identified the world of artificial intelligence research teams with co-authorship network, and then identified the leading team based on the Number of Publications, Number of Citations, H-index, Weighted Degree Centrality, Betweenness Centrality, and Closeness Centrality. Based on the identified artificial intelligence research leading teams, this paper divides different types of cooperation models by region and comprehensively analyzed the three aspects of geographical distribution, cooperation indicators, and cooperation topics in the research teams from the perspective of comparisons. In order to find the international gap between China and other countries, we still highlight the difference between China's participation and non-participation in cooperation. The research results show that Chinese and their foreign research maintain close ties with major scientific research countries; international cooperation is widespread and is conducive to crossing into the leading team; China's domestic cooperation is higher than in other countries, and their domestic cooperation research is mainly manifested in the data processing and application level, while the core technology and basic algorithm levels need to cooperate with foreign countries.

Keywords: research cooperation, cooperation model, artificial intelligence, research team comparative study

1 Introduction

Scientific research cooperation is an activity carried out between scientific researchers through the sharing of scientific and technological resources and teamwork. In the environment of big data, the comprehensiveness, complexity, and interdisciplinary nature of scientific research are becoming more and more obvious, and scientific cooperation has become an inevitable trend (Ma, Li, & Chen, 2015). Analyzing the attributes and relationships of cooperation from different perspectives, the modes of scientific research cooperation show different expressions and characteristics, which in turn reflect different scientific cooperation trends and scientific research development laws. Investigating the scientific research cooperation model from the perspective of the location of the collaborator can discover the distribution, characteristics, and differences in scientific research cooperation between different regions or countries, and distinguish the research status of a country in the world or in certain regions. In addition, it provides a basis for promoting cross-regional or regional scientific communication and policy formulation.

As a comprehensive discipline that has attracted attention from all over the world and is rapidly developing, artificial intelligence (AI) not only produces a large number of scientific research cooperation in the research process, but also has a variety of cooperation modes across regions and fields. Therefore, it is necessary to explore

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and compare the cooperation models of AI research teams from the geographical perspective, analyze the country and geographical distribution of different cooperation models, study the size and performance of the teams under each cooperation mode and their research topics, and provide an in-depth analysis of the AI field. The state of cooperation and development has important research significance.

At present, the international cooperation research situation mainly takes a single paper as the unit of consideration, from the perspective of co-authors and the related attributes of the paper. Zhou and Glänzel (2010) studied the overall and representative characteristics of China's international scientific and technological cooperation using bibliometrics and social network methods; Jin, Richard, Zhang, Cao, Wang and Zhou (2007) used bibliometrics to analyze the cooperative relationship between Chinese and American scientists in scientific papers; Hu, Zhu, Zhang and Chen (2009) used complex network theory to conduct scientific research in the field of supply chain management. The cooperation network conducts empirical research and compares the characteristics of scientific research cooperation models in this field; Guo, Yang and Kuang (2013) used the cooperation rate and cooperation degree to compare and analyze Chinese and foreign library and information cooperation models.

The influencing aspects are to explore the internal and external factors that affect international cooperation, including the nature of the subject field, national research strength, geography, politics, history, society, culture, and language (Pu, Yuan, Yue, & Liu, 2015); for example, Melin (1999) compares Northern Europe and the United States, Eustache Mêgnigbêto (2013) analyzed the scientific and technological cooperation model of multiple countries in western Africa and found that the impact of scientific and technological cooperation in western Africa is mainly reflected in the effectiveness of scientific and technological cooperation in western Africa. Regarding the impact of international scientific research cooperation on scientific research production, for example, Qiu & Zeng (2013) took the field of computer science as an example, using correlation analysis to verify whether international cooperation can improve the scientific research influence; Lee and Bozeman (2005) focused on the author's individual level, analyzing the impact of cooperation on scientific research performance. The existing international cooperation models have multiple research perspectives. However, these studies are mainly based on the co-authoring relationship of single papers to characterize the cooperation models. Most of them use individual scientists as the research base. There is a lack of international cooperation research based on the team of scientists as a whole. There is less research on the content level of cooperation. What is more, a comprehensive and comprehensive discussion on the international AI research field has not yet been conducted.

2 Data and Methodology

2.1 Data Source and Preprocessing

2.1.1 Data Source

This research uses Web of Science (WoS) data for analysis. WoS is one of the most authoritative databases for scientific metrological analysis, and it provides comprehensive coverage of all metadata information from journals, books, and conference proceedings. AI is a complex emerging field. In order to retrieve all relevant documents on this topic, keyword retrieval will encounter the problem of insufficient retrieval rate. In the subject classification of the WoS database, there is an AI subcategory under the computer category, which covers all papers closely related to AI. Therefore, we download all the documents in this subcategory, wherein the inspection rate and accuracy rate are well balanced.

We use the WoS core set as the data source and set the search formula as WC = "Computer Science, Artificial Intelligence", and the index includes SCI-EXPANDED, CPCI-S, CCR-EXPANDED. The time span is 2009–2018, and the data collection date is 2019. On January 16, 421,148 records were obtained. It is well known that conference papers in the computer field are of significant importance. Our search results include journal papers, conference papers, and so on, among which are important conferences in AI-related fields, such as *CONFERENCE ON ARTIFICIAL INTELLIGENCE*, and *INTERNATIONAL CONFERENCE ON INTELLIGENT ROBOTS AND SYSTEMS*. These data can represent research in the AI field as a whole. We download them as basic data and perform data cleaning.

2.1.2 Data Cleaning

Data cleaning mainly includes the name disambiguation of three parts: institution, author, and country. The entire process involves manual review, rule-making, and automated batch processing. First, the amount of

manual tasks for national cleaning is small, and the name expression is easy to summarize. We unified the country names and merged the regions into the corresponding country expressions. After that, processing of the organization name is differentiated according to the country name.

We extract the name of the institution and country to which the document belongs. If the name of the institution is the same but the name of the country is different, it is regarded as a different institution. We manually checked the top 1% of the organizations that issued the documents, combined the different expressions of the same organization based on the aforementioned rules that could not be found, and used the name of the organization with the higher number of documents as the standard. Finally, on the basis of institutional data cleaning, we extract the information about the author's institution and co-authors, and perform author cleaning. The main rules are as follows: authors with the same name in the same institution are regarded as the same author; if there are identical co-authors between authors with the same name, they are judged to be the same author entity; and authors with the same name that do not meet the above two conditions are judged to be different authors.

2.2 Identification of Target Team

After disambiguation of author names, an overall co-author network of all co-authored articles in the data set was constructed by the Louvain method in Pajek. The Louvain algorithm is a community discovery algorithm based on modularity, and its optimization goal is to maximize the modularity of the entire community network (Blondel, Guillaume, Lambiotte, & Lefebvre, 2008).

In all, 94,347 communities were detected through this way. These communities are closely connected and separated from other communities, so they are regarded as research teams formed in a co-authored relationship. The largest of these research teams contains 1,553 authors, and only one of the top 10 teams is under 1,000 (996). We chose to delete the author nodes with a volume of 1 and a citation less than 100 in the original co-author network, in order to retain the research team members who have a certain influence in the field of AI. The overall co-author network has been greatly reduced while maintaining the original important nodes. In order to identify a research team with a reasonable scale and available for analysis, it is necessary to constantly adjust the parameters and compare and evaluate the results of the research team identified under different parameters. When the parameters are set to Resolution=290, Max Level=13, and Max Iteration=13, the granularity that is more suitable for observing the specific situation within the team is reached. The team size is less than 100 people. If the team size is too large, internal connections may be loose. If the team size is too small, some important connections may be missed. It should be noted that there are no strict criteria for the selection of team size and granularity, but the degree of closeness of the revealed research team will be different.

In order to reveal the diversity of the leading team, we use six indicators to measure the research team from different perspectives. They are Number of Publications, Number of Citations, H-index, Weighted Degree Centrality, Betweenness Centrality, and Closeness Centrality (Bonacich, 1972). Among them, the first three indicators measure the strength of the research team from the node attributes, and the latter three indicators measure the strength of the research team from the network structure (Abbasi, & Hossain, 2013). The top 100 teams in each index were screened out, and the top 100 research teams in each index were merged to get 342 teams. Some countries cannot be traced to specific country names and expressed as none, so they are regarded as unknown countries. This research does not consider teams with unclear data for the time being, so as to facilitate the calculation and analysis of the concentration of countries in the later period. Therefore, after removing this part of the team data, 333 teams are obtained as the research object of this article. According to the WoS number, the corresponding text is extracted from the cleaned text data for topic analysis.

2.3 Definition of Related Concepts

2.3.1 Concentrative Ratio

Considering the concentration degree of the author's country in the team, the market concentration measurement indicator (HHI) is applied to this research to calculate the Concentrative Ratio (ConR) in the team as formula (1). The formula is expressed as a ratio of the number of authors in each country to the total number of authors in the team, and then the sum of the squares is calculated. The larger the ConR value, the more concentrated the author's country in the team. The lower the degree of concentration, the more scattered the country the authors belong to in the team. The value of the ratio ranges from 0 to 1. A team with a value of 1 is a single-country cooperative team:

$$ConR = \sum_{i=1}^{N} \left(\frac{X_i}{X}\right)^2 \quad (1)$$

where i is one of the countries in the list set $Country_i$={1,2,..., i,...N}, X_i represents the number of authors in the country, an X represents the total number of authors in the team.

2.3.2 The Dominant Country in the Team

Based on the previous processing, the research target team we obtained was extracted from the co-author's relationship network, and the network was based on multiple papers. Usually, scholars take the co-authors of a single paper as a research group, so scholars will study the order of the authors and whether they are corresponding authors. This research is based on a community group formed from multiple papers, and it is studied from a macro perspective, so the above two aspects are not considered at present.

In addition, considering whether there are differences in cooperative teams led by different countries, this research introduces the concept of the dominant country. The country with the largest number of authors in the team is regarded as the dominant country in the team. We identified the dominant country of each team, and conducted statistics in the international cooperation team to analyze the leading position of each country in the world.

2.4 Division of Team Cooperation Mode

In this study, the research team is divided into two aspects according to the geographical distribution pattern. On one hand, according to the proportion of the number of countries that the authors belong to in the team, it can be divided into two types: single-country domestic cooperation and multinational international cooperation. On the other hand, this study takes the comparison between Chinese and foreign research as the starting point, and calculates the proportion of Chinese collaborators in the team to further divide it into four types, namely, single-country cooperation with China, international cooperation with China's participation, single-country cooperation without China, and international cooperation without China's participation. The specific division is shown in Table 1.

Table 1 gives team cooperation modes and their quantities. The cooperation model of a single country involves 27 teams. Among them, there are 11 teams for domestic cooperation with China and 16 teams without China. There are a total of 306 international cooperation teams, of which there are 148 international cooperation teams without China's participation, and 158 teams are involved in Sino-foreign international cooperation. It is worth noting that this research uses the leading AI team as the research object, and the purpose is to explore the regional cooperation model situation of the international leading team. The main investigation is the research situation of the leading team rather than the overall research situation, and each model is used as a measure. Overall, the difference in the number of leading teams in each mode does not have an impact on this research.

Table 1
Team Cooperation Mode and Quantity Statistics

Team cooperation mode	quantity statistics	Does China participate	
		No	Yes
Domestic cooperation	27	16	11
International cooperation	306	148	158

2.5 Research Design

According to the above research assumptions, based on the identification of AI research teams in the early stage, the main analysis framework designed in this paper is as follows: First, we carry out research on the country distribution and co-occurrence of AI research teams, use Python self-compiled programs to realize the country distribution map of the research team, and analyze cooperation between countries with co-occurrence relationships; second, we carry out comparative research on the cooperation performance of AI research teams, and compare the indicators of each model team from the perspective of multi-index calculation; Finally, a comparative study of the collaborative content of AI research teams is carried out. From the perspective of collaborative knowledge content, spectral clustering is used to form the research topics of different types of teams and conduct comparative analysis. The overall research framework process is shown in Figure 1.

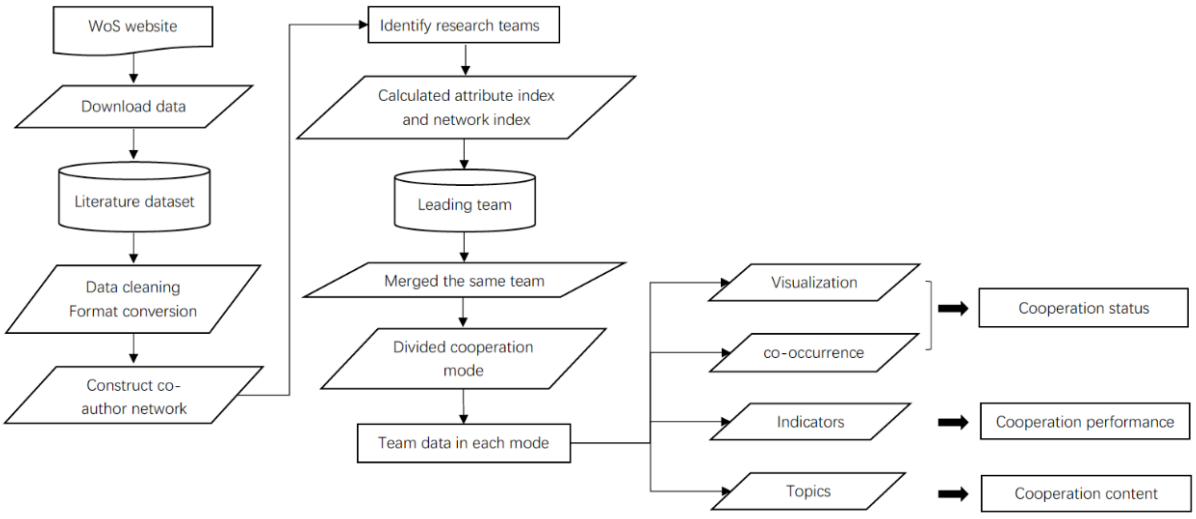

Figure 1 Research framework flow chart.

3 Results and Analysis

3.1 Cooperation Status

3.1.1 Overall Distribution of Countries

A total of 82 countries are involved in statistics on the participation of countries in the team. The statistical results of the number of teams participating in the country are mapped to the world map according to the geographical location, and the statistical distribution of the number of teams in the world is shown in Figure 2. The lightness of the color in the picture indicates the number of participating teams, and the darker the color indicates that the country has more teams participating. The United States has the largest number of teams (201, 58.77% of the total), followed by people's Republic of China (173, 50.58% of the total). As a whole, the main distribution areas are the United States and Canada in North America, China and India in Asia, Australia and developed Western Europe.

At the same time, we conducted a distribution study on the dominant countries. There are 37 countries that dominate the team. Although 45 countries participate in teamwork, they do not occupy the dominant position. Count the number of teams led by countries and display them on the international map as shown in Figure 3. China dominates the largest number of teams (100, accounting for 30.03% of the total), followed by the United States (48, accounting for 14.41% of the total). The number of other leading countries is relatively small, and the number of international teams participating in non-dominant countries is also relatively small. On the whole, the country's dominant position in the team is related to the participating teams.

3.1.2 Multinational International Cooperation

International cooperation is divided according to whether or not China participates. It can be divided into two situations: international cooperation with China's participation and international cooperation without China's participation.

3.1.2.1 International Cooperation without China's Participation

The co-occurrence analysis of multi-country cooperation in this model is shown in Figure 4. The color of the map in the figure indicates the number of teams involved in the country, and the thickness of the line indicates the degree of co-occurrence between countries. It can be seen from the figure that the United States occupies a dominant position in international cooperation under this model, and there are more connections between it and many European countries. According to existing theory (Wang, 2014), countries with the number of co-occurrences with the United States greater than $0.749\sqrt{n_{max}}$ are selected, where n_{max} represents the maximum number of co-occurrences with the United States [11]. A total of 14 major co-occurring countries are obtained: Germany (32), UK (28), India (23), France (19), Switzerland (19), Spain

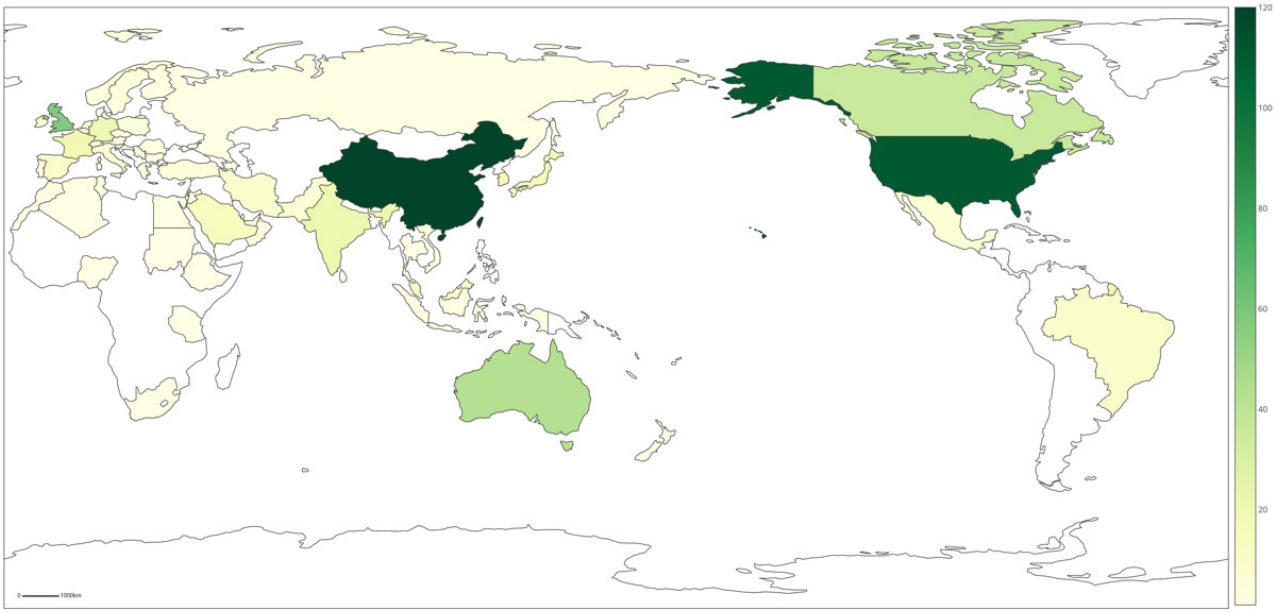

Figure 2. Distribution map of teams participating in countries around the world.

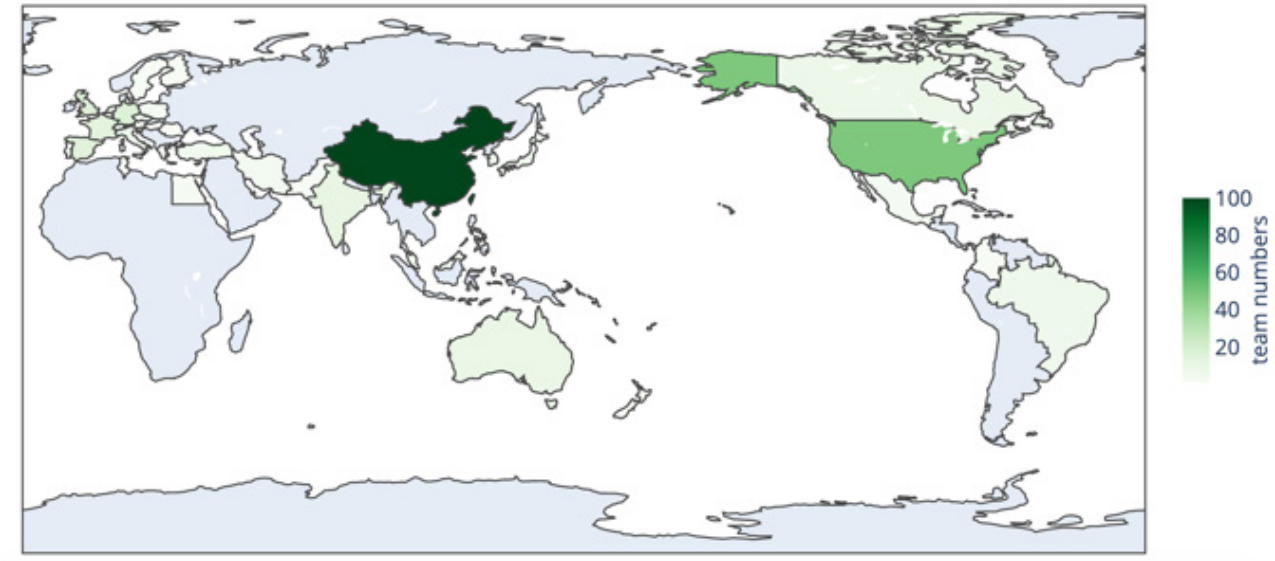

Figure 3. Distribution map of teams led by countries in the world.

(18), Netherlands (14), Italy (13), Austria (12), Canada (10), Japan (9), Belgium (8), and South Korea (8). The number of co-occurring teams is in parentheses. It can be seen that the cooperation between Europe and the United States in the international cooperation of AI is relatively close, and it is mainly manifested in the cooperation between the developed countries in Western Europe and North America. India's AI research also occupies a certain position in international cooperation.

3.1.2.2 International Cooperation with China's Participation

This model represents some groups that conduct academic exchanges between China and other countries. The distribution and co-occurrence of countries in this model are shown in Figure 5. In the figure, China occupies a core position. In addition to China, the United States, Australia, Canada, and Europe are the main connection points, and the connection between China and the United

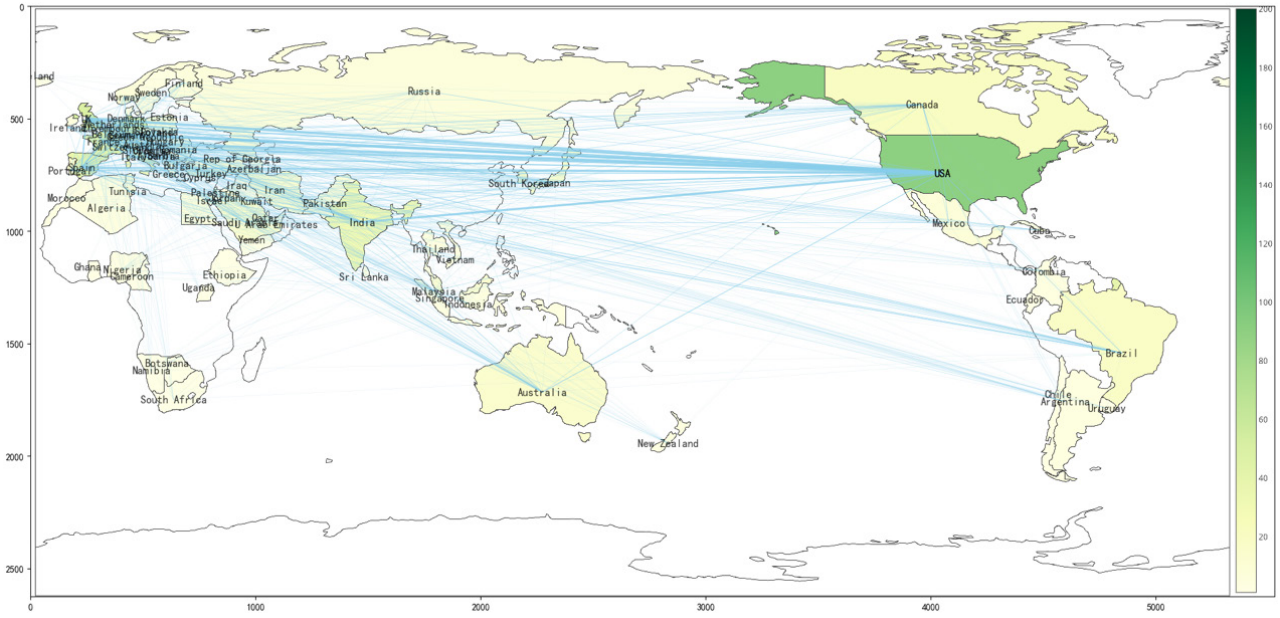

Figure 4. Country distribution and co-occurrence map under the international cooperation model without China's participation.

States is the thickest, indicating that in this model, China mainly cooperates with the United States. We select countries that have a number of co-occurrences with China greater than $0.749\sqrt{n_{max}}$ where n_{max} represents the maximum number of co-occurrences with China. There are 14 major co-occurring countries, namely, the United States (111), UK (57), Australia (43), Canada (36), Singapore (25), India (21), Germany (20), France (19), Japan (17), South Korea (16), Saudi Arabia (14), Malaysia (11), Brazil (10), and Spain (10). It can be seen that China's international cooperation covers a wide range, mainly in North America, Oceania, and Europe. Among the Asian countries that China cooperates with, Singapore is the first.

We identify the dominant country in this model, and count the number of teams and their proportions, as shown in Figure 6. Among the international cooperation teams with China's participation, the number of teams led by China is the largest, followed by the teams led by the United States. There are 8 cooperative teams led by the United Kingdom, 7 cooperative teams led by Australia, 6 cooperative teams led by Canada, 4 cooperative teams led by France, and 3 cooperative teams led by Singapore, India and Japan., Germany, South Korea, and Spain are led by two teams, and the rest are one.

3.1.3 Single Country Domestic Cooperation

The statistics are divided by country, and the number of teams in the country under the domestic cooperation model is ranked. Tracing the specific countries in the single country cooperation model team, there are 14 countries with single country cooperation model, namely Peoples Republic of China (11), Brazil (3), USA (2), and Canada (1), Czech Republic (1), Germany (1), India (1), Israel (1), South Korea (1), Spain (1), Portugal (1), Mexico (1), United Kingdom (1), and Turkey (1). The numbers in parentheses is the number of teams in this type of mode.
The Chinese domestic cooperation model team refers to a cooperative group of domestic experts in China, which also belongs to the cooperation model of a single country. Compared with the number of groups cooperating with other single countries, China has the largest number of cooperating groups. This confirms the large number of Chinese scholars, and the number of groups involving Chinese scholars under this model; on the other hand, it also reflects that some Chinese scholars have limited cooperation.

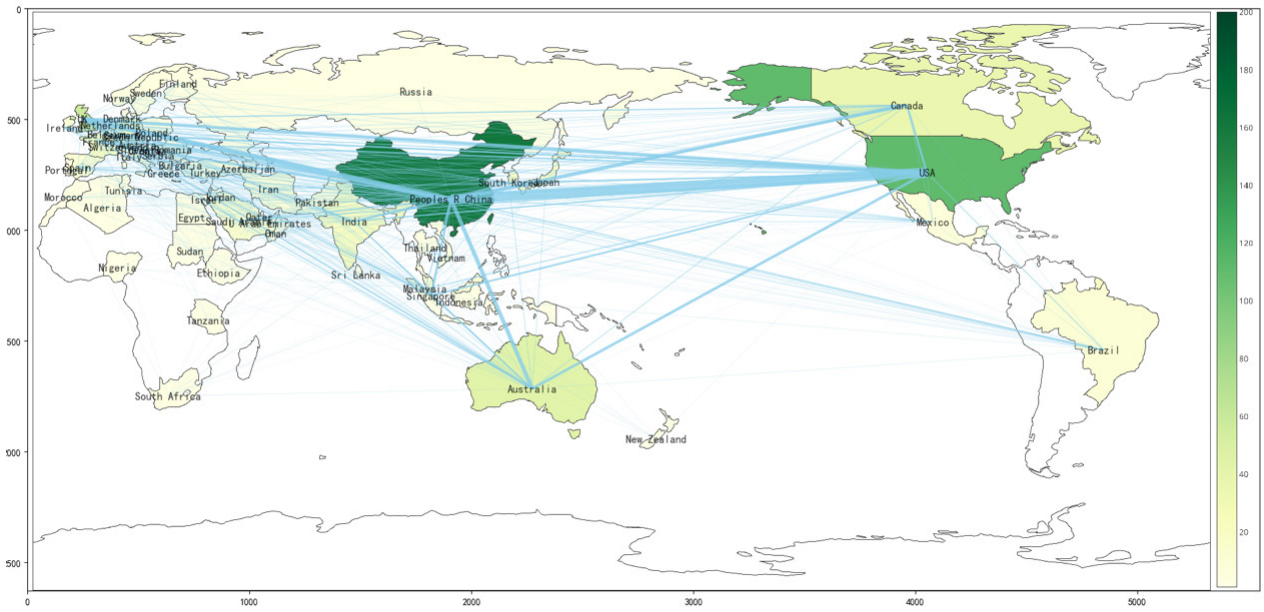

Figure 5. Country distribution and co-occurrence map under the international cooperation model with China's participation.

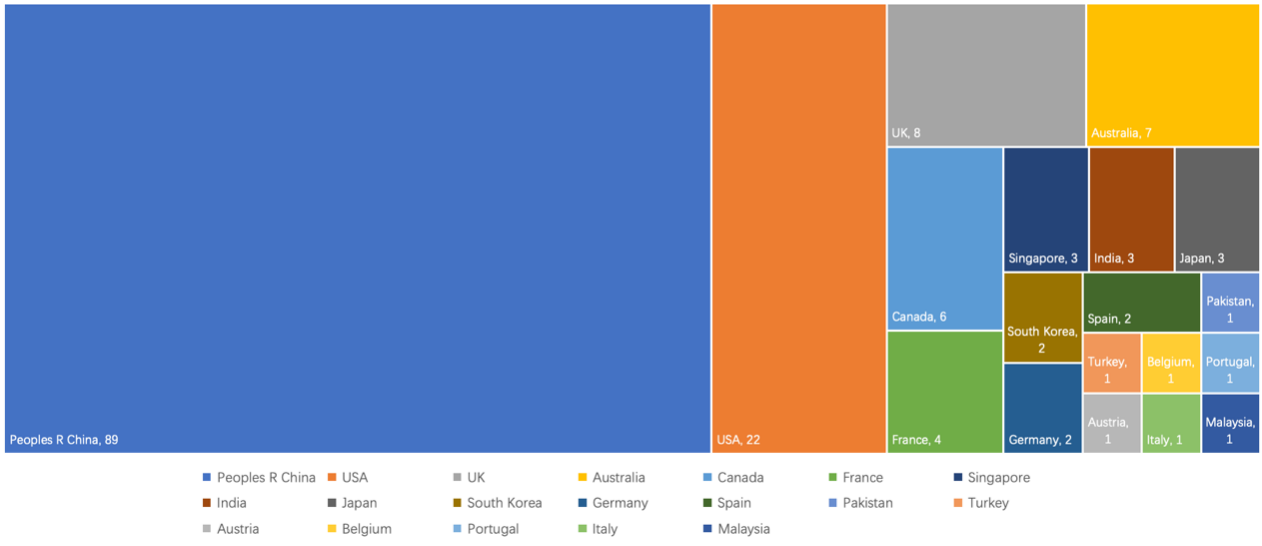

Figure 6. Statistics of the leading country of the team under the international cooperation model with China's participation.

3.2 Cooperation Performance

3.2.1 Cooperation Performance of Different Cooperation Modes

This study counts the number of authors involved in the team under different modes and calculates the number of publications, citations, and H-index in each team based on the principle of score counting. The results of each index obtained are shown in Table 2. As a whole, all indicators present the characteristics of "domestic cooperation < international cooperation". Regardless of whether it is international cooperation or domestic cooperation, the indicator values of the team under the model with Chinese participation are greater than the indicator values of the team under the overall international cooperation model.

The indicator values of the team under the model without Chinese participation are all lower than the overall international cooperation.

It can be seen that China's participation in international cooperation can help improve the research performance of the team, and Sino-foreign cooperation has promoted the output of scientific research results to a certain extent. For China, the performance of international cooperation is higher than that of domestic cooperation, indicating that international cooperation in the field of AI research is of certain importance for entering the leading team.

3.2.2 Cooperation Performance of Different Concentration Ratio

We calculate the concentration ratio of the author's country in each team based on formula (1). In order to more concisely show the performance of teams with different levels of concentration, we further divide the range of concentration levels and calculate the indicators in each range. The calculation results are shown in Table 3. On the whole, the values of the indicators in different ranges are not much different, but there is still a small gap. When the concentration ratio is 1, there are fewer publications and H-index, which is a single country domestic cooperation; when the degree of concentration is in the range of 0–0.2, the values of the three indicators are all low, and the team is too scattered. It can be seen that teamwork needs to have a certain degree of concentration, but it cannot be completely concentrated in one country, that is, international cooperation with major cooperating countries is more conducive to the output of scientific research results.

Table 2
Comparison of Indicators of Research Teams in Each Model

Cooperation mode	Number of authors by teams	Number of publications by teams	Citations by teams	H-index by teams
International cooperation	45.7	95.0	1677.3	85.2
With china	47.2	97.0	1815.5	88.3
Without china	44.0	92.9	1529.8	81.8
Domestic cooperation	26.6	72.6	1577.9	61.4
With China	39.1	102.4	1820.9	85.5
Without China	18.1	52.1	1410.8	44.8

Table 3
Performance in Different Concentration Ratio Ranges

Concentration ratio Ranges	Number of publications by teams	Citations by teams	H-index by teams
[0,0.2)	79.9	807.3	71.4
[0.2,0.3)	101.9	1180.9	79.1
[0.3,0.4)	100.4	1574.6	83.7
[0.4,0.5)	92.1	1650.2	83.4
[0.5,0.6)	88.2	1643.4	78.2
[0.6,0.7)	86.8	2305.9	91.2
[0.7,0.8)	103.3	1363.8	85.3
[0.8,0.9)	92.9	2000.4	92.2
[0.9,1)	105.5	1464.4	86.1
1	72.6	1577.9	61.4

3.3 Cooperation Contents

3.3.1 Multinational International Cooperation

This part of the research separately conducts thematic analysis of the presence or absence of China's participation.

3.3.1.1 International Cooperation without China's Participation

The research topics in this mode are shown in Table 4. The main collaborative research includes various algorithms, such as Differential Evolution, Clustering Algorithm, Support Vector Machine, Neural Network, and Deep Neural Network. The differential evolution algorithm guides the optimization search by imitating the heuristic group intelligence generated by the cooperation and competition between individuals in the biological group. *t-s* fuzzy system and fuzzy rough set are often used in system simulation research (Yuan & Wang, 2006). Robust stability is an evaluation of the model. In the application field, the leading team of major foreign cooperation models mainly focuses on the related research of face recognition. Based on the above research themes, the cooperative research of these teams is mainly at the level of basic algorithm research and basic model level, focusing on basic technology research and model performance.

Table 4
Research Topics of International Cooperation Model Teams without China's Participation

Cluster number	Cluster topics	Cluster number	Cluster topics
#0	Differential Evolution	#5	Support Vector Machine
#1	Neural Network	#6	Robust Stability
#2	*t-s* Fuzzy System	#7	Face Recognition
#3	Sparse Representation	#8	Fuzzy Rough Set
#4	Clustering Algorithm	#9	Deep Neural Network

Table 5
Research Topics of International Cooperation Model Teams with China's Participation

Cluster number	Cluster topics	Cluster number	Cluster topics
#0	Memetic Algorithm	#6	Face Recognition
#1	Multi-Agent System	#7	Computational Modeling
#2	Object Detection	#8	Intrusion Detection
#3	Feature Selection	#9	Parameter-Exploring Policy Gradient
#4	Convolutional Neural Network	#10	Wave energy Facility Location
#5	Humanoid Robot	#11	Data Mining

3.3.1.2 International Cooperation with China's Participation

The research topics of the cooperative model team are shown in Table 5, and the research topics are more detailed. The main research topics in the application field are Humanoid Robot, Face Recognition, Wave Energy Facility Location, and so on. The algorithm level mainly includes the Memetic Algorithm and the Convolutional Neural Network. The former is an optimization algorithm based on simulated cultural evolution proposed by Pablo Moscato. It is a global search based on the population and individual based a combination of the local heuristic search. Research on computer technology includes Multi-Agent System (MAS), Intrusion Detection, Computational Modeling, and so on. The Parameter-Exploring Policy Gradient method in the parameter space is the most effective and powerful policy search method. Based on the above research themes, the collaborative research of AI teams with China's participation highlights the research in the field of robotics. The research at the algorithm level and search strategy level is more in-depth than other models, the research at the data mining and computer technology level is richer, and the overall presentation is that of a computer hardware-based situation.

3.3.2 Single Country Domestic Cooperation

In this mode, we select only China as the research object and analyze the research topics of China's domestic cooperation. The research topics of the team are shown in Table 6. The research topics cover a wide range. Color Space is an important part of image recognition research (Yin, 2017). Face Reconstruction research mainly involves face analysis, model fitting, and image synthesis. These two research themes indicate that domestic cooperation is in progress. Research on face recognition, principal component analysis, and adaptive neural network are commonly used algorithms in the field of AI. The former is often used for dimensionality reduction in data mining. Departure Warning System and Fuzzy Risk Analysis are applied researches at different levels. Rough set and point matching are also commonly used mathematical tools and methods in data processing. It can be seen that the collaborative research of China's domestic AI leading teams is mostly data processing level and application level research, highlighting face reconstruction and color space in face recognition research, and focusing on the effectiveness of algorithm learning.

4 Discussion and Conclusions

Driven by data science, this article analyzes the cooperation model of the leading AI research team from the perspective of the regional cooperation model, and focuses on the comparison of the AI leading team with or without China participating. On the basis of identifying the leading team, divide the research team cooperation mode by region, comprehensively compare and analyze the cooperation mode of AI research team from the geographical distribution, cooperation performance indicators, and cooperation theme content, and highlight the comparative analysis between China and foreign

Table 6
Research Topics of China's Domestic Cooperation Model Team

Cluster number	Cluster topics	Cluster number	Cluster topics
#0	Color Space	#8	Decision-Making Approach
#1	Dynamical Uncertainty	#9	Uncertain Nonlinear System
#2	Face Reconstruction	#10	Clustering Technique
#3	Principal Component Analysis	#11	Rough Set
#4	Frank Prioritized Bonferroni	#12	Point Matching
#5	Adaptive NN	#13	Interval type-2 Fuzzy Set
#6	Departure Warning System	#14	Learning Technique
#7	Fuzzy Risk Analysis	#16	Learning Achievement

countries. The research conclusions obtained are as follows.

From the perspective of cooperation status, international AI research maintains close ties with the major scientific research countries. Teamwork is mainly established between European and American countries, with the United States as the leader, and North American and Western European developed countries as the main cooperating countries; in addition to the major scientific research foreign countries, more Asian countries cooperate with China.

From the perspective of team performance, it is mainly divided into two aspects. On one hand, the performance of international cooperation is better than that of single-country domestic cooperation, and the performance of international cooperation teams with China's participation is higher than that of international cooperation teams without China. On the other hand, teams with different concentration degrees in different countries have different performances. There is no obvious linear correlation between the concentration degrees of countries in the team and performance. However, the performance is relatively poor in both cases of complete concentration, that is, a single country state, and complete decentralization.

From the perspective of cooperation content, international cooperation focuses on research at the level of core technologies and basic algorithms. International cooperation without China's participation is mainly reflected in basic research. International cooperation with China's participation is more detailed and in specific algorithms and computer technologies it is more abundant.

In addition, to support the perspective of China, we integrated the analysis of three aspects of cooperation status, cooperation performance, and cooperation content. China's domestic cooperation is higher than that of other countries, and some Chinese researchers need to expand their circle of cooperation for international cooperation. Increasing international cooperation is crucial to joining a leading AI research team, and leading international cooperation is more conducive to team development. The subject of China's domestic AI cooperative research is mainly reflected in the data processing and application level, while most of the core technologies and basic algorithms are cooperated with foreign countries.

Compared with previous studies, this research starts from the perspective of teamwork, combining country distribution and the presence or absence of China's participation to classify teamwork models. At the same time, it introduces a market concentration index to indicate the concentration index of the country where the authors belong to the team, and perform performance considerations on the identified teams. However, this article still has certain limitations. It only selects literature data as the research object, and uses only China as the comparative country. The future research will conduct multisource data analysis and supplement the research of multiple data sources such as political reports and fund projects. We will try to further explore the differences among the Chinese participating with each of the other countries and work hard to find other supporting materials to enrich the comparison, with a view to more comprehensively and accurately examine the cooperation and research status of international AI research teams.

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