

Knowledge Groups of Hotspot in Teaching and Research of Electromechanical Discipline under the Deep Integration of Science and Education

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Abstract—In view of the shortcomings: "Emphasis on qualitative analysis", "Emphasis on single". This paper used bibliometrics and visualization software of Citespace 5.3. Scientific atlas analysis is about the research status of electromechanical discipline in 2011-2018. It focused on "the whole". It analyzed the research hotspots and the development context of the subject as a whole. It explored the research hotspots of electromechanical discipline through keyword co-analysis, organization distribution, author's volume and the co-author analysis. Meanwhile, revealing the current situation of mechatronics research from the visualization perspective and summarizing and look forward to the future.

Keywords—*Knowledge Graphs; Electromechanical teaching; Visualization; Prospects*

I. INTRODUCTION

At present, with the popularization of information and digital era, the visualization of data have attracted the attention of more and more researchers in the field. The scientific knowledge map is produced in this context. With the help of scientific knowledge maps, the structure of major institutions in the knowledge system can be clearly analyzed. The scientific knowledge map integrates bibliometrics, information metrology, visualization technology, statistics and social network. It is a frontier issue and a hot issue in the current research in a certain field or a certain discipline.

In recent years, it is of great value to keep abreast of the latest developments in electromechanical research. Since the 21st century, the research and teaching of electromechanical science has also shown a vigorous development trend with the reform of education. The research field has gradually expanded, and research results have emerged^[1-2]. Tracking the latest developments and research hotspots of electromechanical research can not only allow scholars to grasp the research direction. It can also provide rich guidance for undergraduate teaching.

It analyzes the results of electromechanical research quantitatively and objectively by using bibliometrics, visualization techniques, and knowledge maps and focusing on the "whole" analysis of the research hotspots and the development context of the whole subject. At the same time,

there are research hotspots and developmental contexts of mechanical design, electrical engineering, mechanics and intelligent control. The research hotspots and development context of control are analyzed to obtain effective data. This article focuses on the analysis of the integrity of the discipline, rather than the judgment and statistics of a single sub-discipline. This paper draws on the future development of electromechanical disciplines through the overall development.

II. HIGH-FREQUENCY KEYWORDS AND EXTENDED KEYWORD ANALYSIS OF ELECTROMECHANICAL DISCIPLINES

The electromechanical discipline contains a wide range of fields. The use of Citespace to extract and analyze the keywords of the article can accurately grasp the key points. According to the keywords, the more popular direction of electromechanical majors can be judged in recent years. In the keyword co-occurrence network diagram obtained by Citespace, the nodes represent keywords, which are marked as crosses. The frequency of keywords appears to indicate that the current researchers and the higher the concern of social-related hobbyists. It also represents the main research direction of current electromechanical research to a certain extent.

A. Keyword analysis of mechanical

It can be seen from Fig. 1 that the research fields in the machinery industry is mainly the following: mechanical movement, agricultural machinery, mechanical properties, fluid beds, mechanical arms, the chemical machinery, fluidized bed, mechanical components, fault tolerant technology, the fault detection. In the figure, the first place in the keyword frequency is mechanical vibration. The study of mechanical vibration is an important topic at the moment. Some authorities have done some research on mechanical vibration. For example, Tan Anquan and Liu Jingxi^[3] have studied the vibration characteristics of composite laminated cylindrical shells based on love shell theory. The results show that the boundary conditions and the axial modes have greater influence on the low-order circumferential modes; Guojie and Zhang Wenping^[4] established the continuum dynamics model of valve train to analyze the dynamic characteristics and excitation source characteristics of valve train. The prediction method was verified by the measured dynamics of valve train and the vibration law of structure surface. Liu Zhihui, Niu

Junchuan^[5] used the finite element method of power flow to solve the bending wave of energy density of the thin plate. The linear quadrilateral mesh was used to mesh the thin plate. They established the finite element equation of the unit on this basis. Furthermore, the energy density response at each node on the thin plate is obtained by assembling and solving the finite element equation of the element.

The second place in Fig.1 is agricultural machinery, followed by mechanical properties, fluid bed and mechanical arm. Manipulator is widely used in various occasions as the output terminal of mechanical intellectualization. For example, the assembly line of a factory. There are more and more factories use robotic arms instead of manpower to recognize and sort objects. It is a very popular research field.

Key word co-occurrence network diagram of machinery industry as Fig. 1.

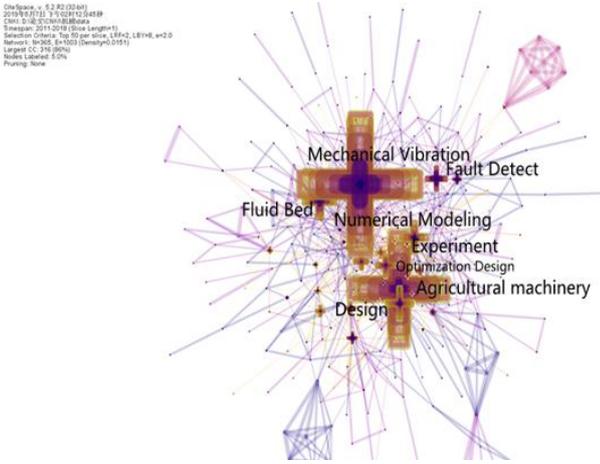


Fig. 1. Key word co-occurrence network diagram of machinery industry

B. Analysis of electrical key words

Electrical professional keywords such as Table I.

TABLE I. FREQUENCY CHART OF KEY WORDS IN ELECTRICAL SPECIALTY

Freq	Burst	Centrality	Keyword
460		0.16	Relay protection
218		0.35	Electrical Equipment
137		0.20	electric
122		0.12	Short circuit
119		0.05	Electronic control system
110		0.03	Intelligent substation
104	11.52	0.13	Schneider Electric

TABLE I shows that the word frequency is in the top eight is relay protection, electrical equipment, electrical, short circuit, electrical system, intelligent substation, Schneider Electric and tourmaline. It can be seen from TABLE I that recent relay protection is the hottest research direction. For example, in 2018, Guan Yadong and Xu Lei^[6] developed the relay protection online payment management system; Cui Yu, Wu Wei^[7] discussed the information synchronization method of system and relay protection statistical analysis and operation management module, state maintenance assistant decision

module. He Chun^[8] introduced the high accelerated life test (HALT) to verify the reliability of the localized protection device, and quickly found product defects, operational design margins and structural strength limits. Li Baoping^[9] applied the embedded real-time operating system to the ship of relay protection device. The device is designed for the system structure. It is based on the ARM9 real-time operating system. It gives the function of each module of the system. It focuses on hardware circuit design for switching acquisition, analog acquisition and switching output modules in the system. The method^[10] for eliminating the current application ignores the large amount of incomplete information during the operation of the relay protection of the circuit system, which often leads to inaccurate fault diagnosis results and seriously affects the problem of the elimination result. A method for adaptive protection of relay protection based on minimum loss of information is proposed.

The second item in the TABLE I is the electrical equipment. It is applied to multiple fields and closely related to life. The highest explosive value available in the picture is Schneider Electric, which is popular, focusing on the development of electrical equipment. There are other keywords with higher frequency which belongs to the secondary field. They also have relatively extensive research value. It can be seen from the figure that the research in the electrical field is a diversified development.

III. ANALYSIS OF RESEARCH INSTITUTIONS IN ELECTROMECHANICAL DISCIPLINES

The organization is the general name for the place where various papers are published. The frequency of citations and articles cited in the organization reflects the contribution of the institution to the overall scientific level. Fig.2 is a distribution diagram of research institutions based on Citespace. The nodes in the figure represent the organization. It is represented by a circle. It is analogous to the cross pattern of the keyword parsing graph. The figure shows the specific volume of publications of each agency and the interconnection between each institution. Through the image, it is possible to have a clearer understanding and analysis of the research progress on the current situation.

A. Analysis of literature publishing institutions in mechanical disciplines

Analysis of mechanical literature publishing institutions as shown in TABLE II.

TABLE II. INSTITUTIONAL LITERATURE STATISTICS

Freq	Centrality	Institution
100	0.05	China Agricultural University
89	0.02	Chinese Academy of Sciences University
86	0.01	State Key Laboratory of Mechanical Transmission, Chongqing University
58	0.03	Northeast Agricultural University
54	0.01	Northeastern University

It can be seen from Table II that the top of the frequency is the Chinese academy of agricultural sciences, the Chinese Academy of Sciences, the State Key Laboratory of Mechanical Transmission of Chongqing University, the Engineering College of Northeast Agricultural University, the school of

Mechanical Engineering and Automation of Northeastern University. The frequency of articles in China Agricultural University is 100. It is in the first place that mainly focusing on the study of agricultural machinery. Agricultural machinery research of China Agricultural University ranks first in China. It is one of the leading institutions in the field of machinery. The Chinese Academy of Sciences has a word frequency of 89 which is in second place. Its main research areas are chemical machinery, tandem robotic arm, 3D printing, and mechanical design of underwater robots. As an authoritative research institution in China, the Chinese Academy of Sciences has an important position in the field of mechanical research in the country, and its research direction has a certain representativeness.

The key frequency of the state key laboratory of mechanical transmission of Chongqing University is 86 which is in the third place. There's a lot of research on it: mechanical vibration, the robot arm, mechanical stress analysis, mechanical modular control. The frequency of the School of Engineering of Northeast Agricultural University and the School of Mechanical Engineering and Automation of Northeastern University are located in the fourth and fifth places respectively. They are engaged in the same direction as the first three. The grasp of the future development direction of the discipline needs to be referenced by institutions with relatively high frequency of words. These institutions represent the latest development direction and development progress of the mechanical discipline. From the above analysis, it is concluded that the main research fields are agricultural machinery, the robot arm, intelligent control, new directions of integration machinery and other professions.

B. Analysis of literature publication institutions in electrical disciplines

Network diagram of the publishing agency of electrical literature based on citespace as Fig. 2.

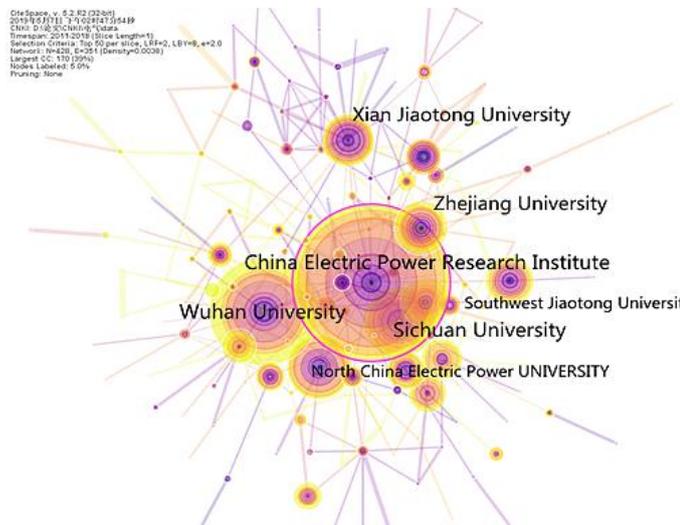


Fig. 2. Network diagram of the publishing agency of electrical literature based on citespace

According to Fig. 2, there are the China Electric Power Research Institute, the Wuhan University School of Electrical Engineering, the School of Electrical and Information

Engineering of Sichuan University, the School of Electrical and Electronic Engineering of North China Electric Power University, and the School of Electrical Engineering of Zhejiang University at the forefront. Among them, the Chinese Academy of Sciences ranked first with 132. It main research includes the performance of electrical equipment, such as UHV, which is the pioneering institution of national electrical research and plays a leading role. The second place is Wuhan University. The word frequency is 90. It mainly studies electrical performance, electrical performance of various media, fault detection, and relay protection. It is also one of the leading institutions in the country. The third place in the word frequency is the School of Electrical and Information Engineering, Sichuan University. It mainly focuses on electrical performance, fault detection and electrical equipment. It is also a research front in the electrical field. In summary, it can be seen from these institutions that electrical equipment and electrical performance are hot areas of current research.

IV. COMPREHENSIVE ANALYSIS AND CONCLUSION

A. Analysis of mechanical disciplines

The main development directions of mechanical disciplines are obtained through the analysis of the common word analysis method, word frequency analysis method, the selection of keywords in literature, and the field of institutional research. Through the keyword analysis, it is concluded that the current attracting scholars focus on mechanical vibration, agricultural machinery, mechanical properties, fluid beds, robot arms, the chemical machinery. The most popular research of them are mechanical vibration and intelligent manufacturing. With the integration of mechanical vision and information technology, mechanical processing accelerates the pace of intelligence. This article analyzes the co-words of the organization. The research directions in the top three were agricultural machinery, the robot arm and intelligent control. China's agriculture ranks second in the world^[15], becoming the agricultural power after the United States. However, there is still a large gap between the mechanization technology and level of agriculture in China compared with other agricultural powers. Agricultural machinery as a hot area is determined by national conditions. In the future, it will continue as a hot spot. As a major trend in the moment, all walks of life are moving in this direction, and the mechanical discipline is no exception. This will also be an inevitable trend in mechanical modernization.

After data analysis, the major interests of mechanical discipline scholars are mainly mechanical vibration, performance research and intelligence of robots and various robotic arms, as well as some new interdisciplinary directions, such as the chemical machinery. Mechanochemistry is a combination of mechanical processing and chemical reactions at the molecular level, including mechanical comminution, chemical reactions under mechanical pressure, friction, mechanical degradation of polymers, cavitation effects, ultrasonic physico chemicals, and molecular periods. Mechanochemistry can be seen as an interdisciplinary subject between the chemical industry and the mechanical industry. It is also a hot trend, as well as agricultural machinery.

B. Analysis of Electrical Discipline

The article uses the same method as the mechanical literature to make statistics. Firstly, through the keyword co-occurrence analysis, the more popular directions are relay protection, electrical equipment, electrical, short circuit, electronic control system, intelligent substation, power equipment. Among them, there are 621 relay protections. It is accounting for one tenth of the total and indicating that relay protection is a hot topic at the moment. Then, there are electrical equipment and electrical systems; these are the hottest research frontiers. The most popular directions from data analysis are electrical equipment, the circuit control, and relay protection.

Through comprehensive analysis of these data, it can be seen that the most popular ones are relay protection, electrical equipment, electrical systems, electrical performance, and intelligence. It is popular in various organizations by analyzing electrical properties, such as studying dielectric properties. There is also intelligent inquiry, and interspersed cooperation with the machinery industry. Inter-disciplinary mutual learning and mutual reference are also the inevitable trend of development.

C. Conclusions and Prospects

At present, electromechanical disciplines as a popular research major that needs to pay more attention to undergraduate education. The results of the study show that popular directions include mechanical vibration, knowledge of the robotic arm, intelligence, robotics, etc. The teaching of mechanical discipline should start from these directions. The relevant courses involved can be focused on, such as intelligent learning through the establishment of pattern recognition, intelligent control and other courses. Through data analysis, this paper concludes that the teaching of electrical disciplines can focus on courses in relay protection, electrical systems, electrical equipment, and intelligence. Especially, it is the study of intelligent direction. At the same time, it is worth promoting students to study across professions. Electromechanical disciplines should open more courses related to other majors, they can enrich the knowledge of students. In the context of informatization and dataization, multi-professional cooperation and development is an inevitable trend. Students need to learn relevant knowledge and keep up with the development of the times.

This article is aimed at SCI, EI, and literature in core journals for the past eight years. The article discusses the development frontiers of mechanical and electrical that are in the first-level and sub-disciplinary research fields. It visually analyzes the data. The article draws on the development prospects of electromechanical related fields in China for nearly eight years. In the next study, it can expand the types of journals in literature and increase the amount of data collected. It is expected that the electromechanical undergraduate education will be better implemented by more comprehensive research.

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