Front. Eng. Manag. 2020, 7(1): 159–162
https://doi.org/10.1007/s42524-020-0094-4

COMMENTS

Botao ZHONG, Luting QIU

Engineering management: Global engineering research frontiers

"Engineering Fronts 2019" focuses on the major research and technology directions that are forward-looking, pioneering, and exploratory in the field of engineering science and technology. It has a significant impact on and results in the future development of engineering science and technology (Center for Strategic Studies of Chinese Academy of Engineering et al., 2019). The exploration of the research frontiers of engineering management is conducive to understanding the development trend of engineering science and technology and leading the new direction of engineering management science and technology revolution.

The frontier selection of engineering research is based on data analysis, research, and judgment and follows the principle of combining quantitative analysis with qualitative research, data mining, and expert argumentation (Center for Strategic Studies of Chinese Academy of Engineering et al., 2019). The research process is divided into three stages: Data exchange, data analysis, and expert review. Figure 1 shows the specific implementation process: The green part is dominated by data analysis, and the purple part is dominated by expert research and judgment.

In the data exchange stage, experts in engineering management and library information interacted to clarify the scope of data mining. Relying on Clarivate, the fields of Web of Science was matched and mapped with the Engineering Management Department to obtain the corresponding core journals and conference lists. After the correction and supplementation by experts, the sources for data analysis in engineering management fields were determined to be 772 journals and 972 conferences. In addition, for comprehensive journals such as *Science*, single-article classification was adopted to determine the articles belonging to the engineering management field. A total of 42322 papers with the highest citation frequency were selected on this basis, taking into account the differences among journals and conferences, publication year, and other factors. The papers were all published between January 2013 and December 2018, and the citations were up to February 2019.

In the data analysis stage, the above 42322 high-cited papers were clustered through the citation clustering analysis. Single-link clustering was applied to delete publications without sufficient co-citation and only loosely linked to the large cluster ($N > 50$), thus obtaining 4240 clustering topics and their corresponding 18321 high-impact papers. Through a comprehensive consideration of the number of core papers, total citation frequency, proportion of frequently cited papers, average publication year of core publications, and other factors, 60 literature clustering topics were selected, including 25 clustering topics published from 2017 to 2018. At the same time, domain experts nominated engineering management hotspots and customized mining according to keywords, finally obtaining 84 literature clustering topics.

In the expert research and judgment stage, field experts conducted an in-depth interaction with data and determined the final research frontiers through discussions, questionnaire surveys, and other methods. Domain experts studied the core papers corresponding to 84 clustering topics and optimized the clustering results. At the same time, the second round of expert nomination was carried out to check the omissions and make up for the deficiencies by comparing these with the literature clustering results provided by Clarivate Analytics. Through questionnaires and multiple rounds of discussions, domain experts merged, revised, and refined the engineering research front topics obtained through data mining and expert nomination, and finally the research frontiers of engineer-

Received January 1, 2020

Botao ZHONG (✉), Luting QIU
School of Civil Engineering & Mechanics, Huazhong University of Science & Technology, Wuhan 430074, China
E-mail: dadizhong@hust.edu.cn

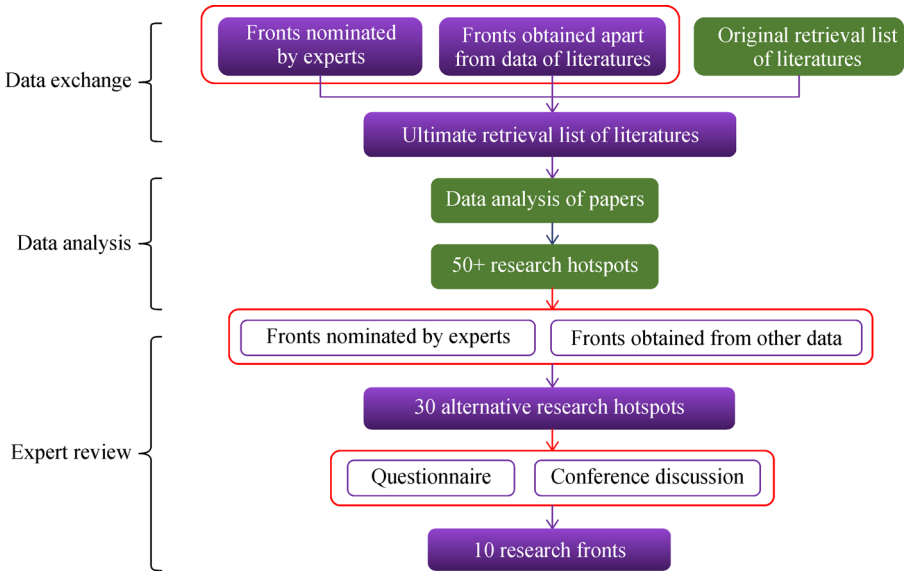

Fig. 1 Implementation flow chart of engineering frontier research.

ing management were selected (Center for Strategic Studies of Chinese Academy of Engineering et al., 2018).

In the field of engineering management, the fronts of global engineering research focuses on 10 parts: (1) research on sustainable development in the Industry 4.0 era, (2) construction management driven by machine vision, (3) resilience of the infrastructure systems, (4) application of big data in remote health monitoring systems, (5) effect of high-speed railway networks on urban development, (6) description of shared socio-economic pathways and their expansion, (7) building information modeling (BIM) and safety management, (8) analysis and research on the Internet of Energy (IoE), (9) logistic trading and shipping management under the Belt and Road Initiative (namely, the Silk Road Economic Belt and the 21st Century Maritime Silk Road), and (10) research on blockchain alliance of energy exchange (Center for Strategic Studies of Chinese Academy of Engineering et al., 2019). The core papers related with these 10 parts are shown in Table 1. Generally speaking, the research frontiers reflect the application trend of artificial intelligence and big data in the field of engineering management.

(1) Research on sustainable development in the Industry 4.0 era

The essence of Industry 4.0 is the digitalization of industrial production. By making full use of the combination of information and communication technology and cyber-physical system, the traditional manufacturing industry will be transformed into an intelligent one. The promotion of Industry 4.0 has put forward new requirements on the production mode value chain system, industrial form, business model, and management upgrade of traditional engineering management. The system frame-

Table 1 Top 10 research frontiers in engineering management

Serial number	Frontiers of engineering research	Number of core papers	Total citation	Avg. citation	Avg. publication year
1	Research on sustainable development in the Industry 4.0 era	22	486	22.09	2017.2
2	Construction management driven by machine vision	17	424	24.94	2016.6
3	Resilience of the infrastructure systems	28	691	24.68	2017.3
4	Application of big data in remote health monitoring systems	33	703	21.30	2016.1
5	Effect of high-speed railway network on urban development	34	771	22.68	2015.4
6	Description of shared socioeconomic pathways and their expansion	20	789	39.45	2016.6
7	BIM and safety management	8	100	12.50	2017.1
8	Analysis and research on the IoE	6	143	23.83	2017.0
9	Logistic trading and shipping management under the Belt and Road Initiative	9	107	11.89	2017.6
10	Research on blockchain alliance for energy exchange	5	108	21.60	2017.6

work and key technologies of Industry 4.0, the global industrial development strategy, the coupling between Industry 4.0 and circular economies, and the construction industrialization are the four typical areas of the sustainable development of engineering in the Industry 4.0 era.

(2) Construction management driven by machine vision

Machine vision is the realization of human visual functions with computers, including the perception, recognition, and understanding of 3D scenes in the objective world and the acquisition, processing, and analysis of digital images. With the development of signal processing theory and computer technology, the machine vision system is widely used in the field of construction, such as safety monitoring, productivity analysis, and defect detection of large infrastructure facilities (e.g., roads, bridges, tunnels, etc.). Identifying and monitoring unsafe construction behavior and state on the basis of machine vision are difficult, thus being hot topics.

(3) Resilience of the infrastructure systems

Infrastructure system refers to the network of engineering facilities providing basic services for social production and residential life, including electric power, natural gas, transportation, water feed and drainage, communication system, and other related systems. Resilient infrastructure systems, which can maintain certain basic functions after a disaster and restore normal functions quickly, have become the target of active construction in many countries. Determining how to evaluate and improve the resilience of infrastructure systems and other key scientific issues is the international research hotspot in urban planning, civil engineering, and industrial engineering.

(4) Application of big data in remote health monitoring systems

Building cloud-based regional health big data platforms and using remote health monitoring systems can facilitate the interaction among hospitals, doctors, patients (and their families), and medical devices, which can provide patients with more accurate diagnostic suggestions and better personalized treatment solutions, help realize the closed-loop of user health management, and directly drive basic health bodies to conduct intelligent medical health management services. At present, the application of health big data are still in the exploration stage. The research difficulties and hotspots mainly include the intelligent integration of health data, construction of health big data platforms, closed-loop construction of health management, data interaction of multiple medical institutions, and health data mining technology.

(5) Effect of high-speed railway networks on urban development

High-speed railway has a significant impact on urban social economy and spatial structure, bringing new opportunities and challenges to sustainable urban development. Current research concerns include the following: Optimizing high-speed railway networks to promote urban transformation and development; optimizing the layout of high-speed railway and promoting their balanced construction in urban areas; improving the construction of high-speed railway to guide the healthy competition of cities; researching the development model of high-speed railway with the goal of avoiding urban quantitative growth and short-term profit; realizing a seamless connection of high-speed railway, aviation, and common railway under the background of big data and artificial intelligence; integrating the urban development strategy into the site selection and design of high-speed railway; and enhancing the organic connection between the selection, design, and construction of high-speed railway stations and the local ecological, economic, social, and cultural environment of the city.

(6) Description of shared socioeconomic pathways and their expansion

The concept of shared socioeconomic pathways (SSPs) is the new scenario framework for the research of land utilization–ecological environment–climate change system. SSP reveals the interrelationship and internal logic between climate change and social and economic factors. The framework considers six key elements, such as population, human development, economy and lifestyle, policies and institutions, technology, and environment and natural resources, as well as five paths, including sustainable development, intermediate, regional rivalry, disequilibrium, and fossil-fuel-based development path. Studying the multi-factor coupling mechanism of SSPs and analyzing the dynamic change of land under different paths with the use of land resources as the carrier have been hot topics in recent years.

(7) Building information modeling and safety management

Building information modeling (BIM) is currently one of the most valuable methods to enhance the effect of safety management, which coordinates a project starting from the design and construction to the operation process with information as the foundation. It builds an integrated process of full digital security management-related processes (i.e., process visualization, simulation, optimization, interaction, coordination, etc.). At present, the key issues in the research focus of BIM and safety management are as follows: Automatic safety review method for the BIM, 3D–*n*D engineering safety simulation and analog analysis method, safety management information control method integrating other technologies, and analysis method of engineering security risk scenario based on image data, etc.

(8) Analysis and research on the IoE

Energy Internet is a new type of energy system with electric power as the core and the Internet deeply integrated based on electronic information technology. At the same time, multi-energy physical interconnection and transparent data interconnection of energy resources are realized. With the close coupling of renewable energy, natural gas, transportation, and other networks, Energy

Internet has become a new focus of international scientific research and industrial development. At present, the research focus of Energy Internet technology innovation are as follows: Construction of general structure and standard system; construction of networking and interoperability model; development of modeling, simulation, and analysis technology; development of operation and control equipment; and construction of safety protection system, etc.

(9) Logistic trading and shipping management under the Belt and Road Initiative

With the further development of the Belt and Road Initiative, the basic strategic significance of the logistics channel is expressed. As the economic link along the route, the Initiative realizes the coordinated development of the regional economy. The innovative development of the talent supply chain and the internationalization of logistics standards are the future development directions. At the same time, the logistics channel carries the opportunity for China's economic and trade development. Identifying the means to establish an early warning mechanism to deal with threats, such as geopolitics, exchange rate, and ecology, through representational changes as well as an economic closed loop of corridors at home and abroad to realize the collaborative innovation and development of "logistics, economy, trade, and industry" is a future research direction.

(10) Research on blockchain alliance for energy exchange

Blockchain is a distributed data management method that transforms the management of transaction participants from centralized control to distributed collaboration. Multi-party sharing mechanism enables multiple participants to form a blockchain alliance, with each participant able to access, maintain, and share the database. Blockchain technology enables the direct transmission of energy supply contracts between producers and consumers, opening up more channels for capital operation and transaction management in the energy sector. Determining how to improve the computing power, storage capacity, and processing capacity of the blockchain and clear cross-industry open standards is of great significance for promoting the in-depth commercial application of the blockchain technology in the energy field. This is also an important research direction in the future.

With the principle of taking experts as the core and data as the support, the method of multi-round interaction between experts and data and iterative selection and judgment is adopted to realize the deep integration of experts' subjective judgment and objective data analysis, which improves the professionalism and academic nature of research and judgment (Center for Strategic Studies of Chinese Academy of Engineering et al., 2019). The current selection of journal and conference papers indicates that project management has systematic, comprehensive, and basic characteristics of complexity. Published data still have a certain lag problem. The follow-up project and cutting-edge research will further optimize the raw data range and interactive feedback mechanism into the ideas of experts' project work and further enhance the directivity and expansibility of the frontier.

References

Center for Strategic Studies of Chinese Academy of Engineering, Higher Education Press, Clarivate Analytics (2018). Engineering Fronts 2018. Beijing: Higher Education Press

Center for Strategic Studies of Chinese Academy of Engineering, Higher Education Press, Clarivate Analytics (2019). Engineering Fronts 2019. Beijing: Higher Education Press