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Research on the Application and Development Trend of Blockchain Technology Patents in the Field of Medical and Health Information

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Abstract:

Objective: To analyze the patents of blockchain technology in the field of medical and health information worldwide. *Methods:* Based on patent data from the Orbit patent database from 2009 to 2020, we adopted patent analysis and social network analysis to conduct a deep exploration of the application trend, distribution of technology research and development institutions, key areas of research and development, and cooperation networks. *Results:* A total of 1,927 sample data of invention patents for blockchain technology in the field of medical and health information were obtained worldwide, with 1,660 valid patents (86.1%). China has the largest number of patent publications (615), but the United States has the largest number of patent priorities (1,031), indicating a strong awareness of global patent layout among US patent applicants. Blockchain technology has been applied in various fields such as healthcare informatics, electronic digital data processing, digital information transmission, diagnosis, and identification. *Conclusion:* Blockchain technology in the field of medical and health information is in a rapid development phase. China should strengthen its awareness of global patent layout and further enhance research and development, as well as cooperation in technologies such as data identification, data representation, recording carriers, and transmission devices.

Keywords:

Blockchain
Medical and health information
Patent analysis
Social network analysis
Competitive situation

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1. Introduction

Blockchain, as a distributed ledger technology, requires joint maintenance by multiple parties and ensures the security of data transmission and access through cryptography, thus guaranteeing the consistency, tamper-resistance, and non-repudiation of data storage [1]. Data processing in the field of medical and health information is currently one of the hotspots of blockchain research.

The "Blockchain White Paper 2019" released by the China Academy of Information and Communications Technology states that the application scenarios of blockchain in the medical and health information field primarily include accessing patients' past medical history data, utilizing data to build models for medical image retrieval and review, and assisting doctors in health-related consultations and disease treatments [2]. Given that patent documents cover more than 90% of the latest global invention and creation information, some scholars have analyzed and studied blockchain technology from the perspective of patent documents. Wang *et al.* used patent map analysis to investigate the major research and development institutions in the domestic blockchain field [3]. Yuan *et al.* analyzed the primary research and development institutions, distribution areas, technical fields, and research and development prospects of blockchain technology worldwide [4]. Lei *et al.* employed bibliometric methods to analyze the current status of basic research and patent technology innovation in global blockchain technology [5]. Liu *et al.*, based on patent analysis, compared the competitive situation between China and the United States in the blockchain technology field, summarized the key technologies of the two countries in this field, and proposed opportunities and challenges for China's blockchain technology [6]. However, there is currently no research focusing on the research and development status of blockchain technology in the medical and health information field. This article, from the perspective of patent analysis, systematically reviews the research status of blockchain technology in the medical and health information field at home and abroad, providing references for related studies.

2. Materials and methods

2.1. Data source

The data source for this study is the global patent database Orbit (https://orbit.com/) developed by Questel, a French company. This database includes patent data from 99 countries and regions, including the China Intellectual Property Office (SIPO), the World Intellectual Property Organization (WIPO), the European Patent Office (EPO), and the United States Patent and Trademark Office (USPTO). It also covers full-text patent information from 24 countries and regions, as well as design patent data from 14 countries and regions.

2.2. Search strategy

In the Fampat database of Orbit, relevant keywords related to blockchain technology were used as search elements, supplemented by the International Patent Classification number (IPC: G16H+, which refers to information and communication technology specially adapted for handling or processing medical or healthcare data). Additional searches were conducted from the perspectives of major applicants, inventors, synonyms, and near-synonyms. Since the emergence of Bitcoin in January 2009 marked the first relatively complete application of blockchain technology, the application date was limited to the period from January 1, 2009, to September 17, 2020. The search formula was as follows: (blockchain OR digital timestamp OR genesis block OR distributed ledger OR decentralized OR trustless) /TI/AB/CLMS AND (G16H+) /IPC.

2.3. Data cleaning and statistical analysis

Before analysis, this study performed standardized cleaning on fields such as organization names, personnel, and keywords obtained through searching to ensure the accuracy of the results. Social network analysis is a measure of the set of relationships between social actors as nodes, specifically including centrality analysis, network density, cohesive subgroup analysis, and core-periphery analysis [7]. Centrality is an important indicator that measures the degree of centrality of an individual in the entire network. Degree centrality is one of the commonly used network centralities, which reflects the correlation between a certain node in the entire network and other nodes. The higher the absolute and relative degree centrality values of a node, the higher the node's importance in the network [8]. The International Patent Classification (IPC classification) is an internationally recognized patent document classification system. Since a patent can simultaneously contain one or multiple IPC classification numbers, for those patents containing two or more IPC classification group numbers, statistical analysis was conducted on the frequency of their IPC main groups. These data were then converted into a co-occurrence matrix, and social network analysis was

employed for co-occurrence analysis of IPC main groups. This study utilized software such as Excel and Python for cleaning, analysis, and visual presentation. Additionally, the social network analysis and visualization tool UCINET were primarily used to draw IPC co-occurrence network diagrams, revealing different technical branches and research hotspots in this field.

3. Results

3.1. Overall application trend and technology lifecycle

A total of 1,927 sample data of invention patents for blockchain technology in the global medical and health information field were obtained, including 1,660 valid patents (86.1%) and 267 invalid patents (13.9%) due to revocation, expiration, and abandonment. In 2009, the number of applications for blockchain technology in the medical and health information field was only 34. The first inflection point of growth appeared in 2010, followed by a slight increase in 2011. The development remained stable from 2012 to 2015. The second rapid growth inflection point emerged in 2015, and since 2016, the technology has entered a phase of rapid growth, with the number of applications reaching 451 in 2018 alone (**Figure 1**).

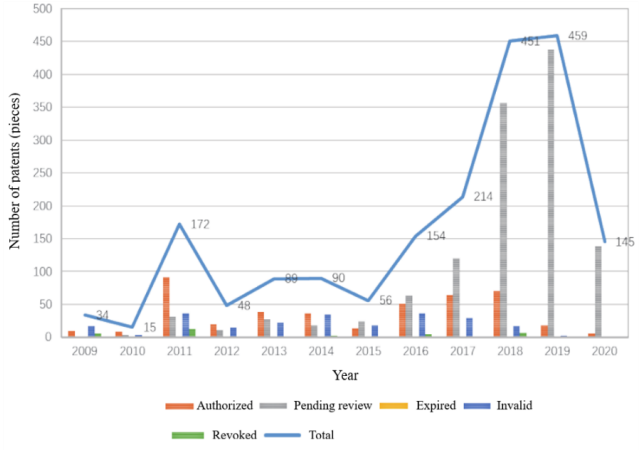

Figure 1. Patent application trends of blockchain technology in the medical and health information field

The assessment of the technology lifecycle is based on a graph with the number of patent applications as the x-axis and the number of patent applicants as the y-axis. This graph reflects the trend of development between the two over time and is also known as the technology lifecycle graph method [9]. The lifecycle of blockchain technology in the medical and health information field aligns closely with the patent application trend. From 2009 to 2014, it was the technological germination stage. A turning point occurred in 2015, with a year-by-year increase in patent applicants and applications, indicating the entry into a phase of rapid technological growth (**Figure 2**).

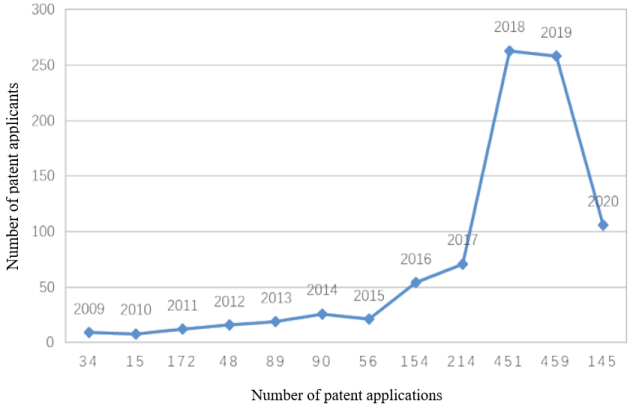

Figure 2. Technology lifecycle of blockchain in the medical and health information field

3.2. Distribution of technological research and development regions

3.2.1. Distribution of countries or organizations for technology disclosure

The top five countries or organizations in terms of the number of sample patents are China, the United States, the World Intellectual Property Organization, Japan, and the European Patent Office. The total number of patents is 1,522, accounting for 79.0% of the total sample patents. China ranks first with 615 patents. Countries or organizations are paying attention to applying for international patents through the Patent Cooperation Treaty (PCT). For example, the World Intellectual Property Organization has disclosed 209 patents, accounting for 10.8% of the total sample patents and ranking third in patent disclosure. Other countries with more than 50 patents include South Korea, Canada, Australia, and India, while the total number of patents from other countries or organizations is less than 30 (**Figure 3**).

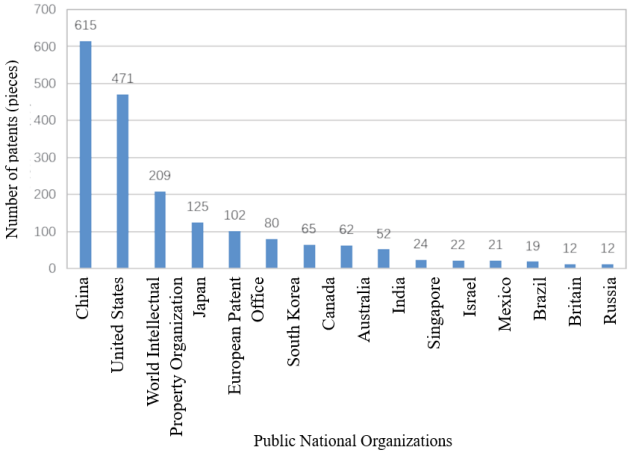

Figure 3. Countries or organizations where blockchain patent applications in the field of medical and health information are publicly disclosed

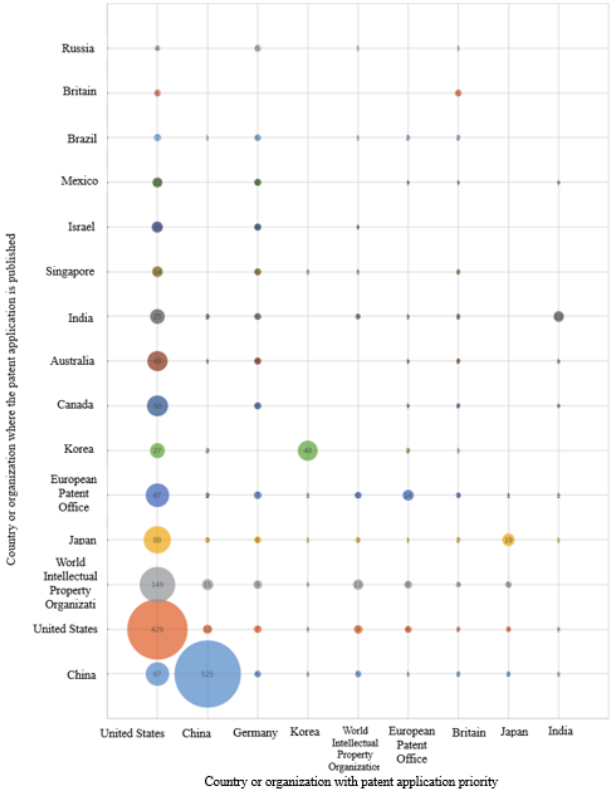

Figure 4. Patent layout of priority countries or organizations in blockchain technology in the field of medical and health information

3.2.2. Distribution of countries or organizations for technology origin

The global distribution of countries or organizations with more than 20 patent priorities is shown in **Figure 4**. The United States ranks first, with 1,031 patent priorities. Apart from applying for 429 patents domestically, it has also conducted a comprehensive patent layout globally, emphasizing patent applications through the PCT route (149 cases). China ranks second, with 565 patents. Besides applying for 40 patents overseas in regions like the United States, Japan, and Australia, the remaining 525 patents are focused on the domestic market. Germany ranks third, with 90 patent priorities and nine PCT patent applications.

3.3. Distribution of technological research and development institutions

The top 10 institutions in terms of blockchain patent applications in the medical and health information field are listed in **Table 1**. There are four institutions from the United States, four from China, one from Germany, and one from Israel. Three institutions from the United States are among the top five globally, including the University of California with the highest number of patent applications, and two companies, DEKA PRODUCTS and ENLITIC. The leading institutions in China are the Chinese University of Hong Kong, Ping An Technology Co., Ltd., Taikang Insurance Group Co., Ltd., and Tencent Technology Co., Ltd.

3.4. Distribution of IPC technology research and development focus areas

Currently, the top 10 IPC technology groups and their interpretations in terms of blockchain patent quantity in the global medical and health information field are mainly concentrated in five IPC technology subclasses: G16H (Health Informatics, i.e., information and communication technology specially adapted for handling or processing medical or healthcare data), G06F (Electric Digital Data Processing), H04L (Transmission of Digital Information), G06Q (Data Processing Systems or Methods, Specially Adapted for Administrative, Commercial, Financial, Managerial, Supervisory, or Predictive Purposes), and A61B (Diagnosis; Surgery; Identification). Specifically, G16H-010, G16H-050, and G06F-021 are the three most

Table 1. Major patent holders of blockchain patent applications in the field of medical and health information

Ranking	Patent holder	Type	Country	Number of patents
1	University of California USA	University	United States	101
2	DEKA PRODUCTS	Enterprise	United States	88
3	B. Braun Melsungen AG Germany	Enterprise	Germany	79
4	ENLITIC	Enterprise	United States	45
5	The Chinese University of Hong Kong	University	China	41
6	Ping An Technology Co., Ltd.	Enterprise	China	40
7	CATHWORKS	Enterprise	Israel	30
8	DEXCOM	Enterprise	United States	25
9	Taikang Insurance Group Co., Ltd.	Enterprise	China	24
10	Tencent Technology Co., Ltd.	Enterprise	China	22

Table 2. Annotation table of the top 10 IPC major groups in terms of the number of blockchain patents in the field of medical and health information

Ranking	IPC major group	Number of patents	Interpretation
1	G16H-010	788	ICT specifically used for processing or handling patient-related medical or healthcare data (medical reports in G16H15/00; treatment or health improvement plans in G16H20/00; for processing or handling medical images in G16H30/00) [2018.01].
2	G16H-050	299	ICT specifically suitable for medical diagnosis, medical simulation, or medical data mining; specifically suitable for detecting, monitoring, or modeling epidemics or infectious diseases [2018.01].
3	G06F-021	290	Security devices for protecting computers, their components, programs, or data from unauthorized actions [8, 2013.01].
4	G06F-019	285	Computational theoretical chemistry; computational materials science; technical subjects not included in other groups of this subclass [2019.01].
5	G16H-040	278	ICT specifically used for arranging or managing healthcare resources or facilities; ICT specifically used for operating or running medical equipment or devices [2018.01].
6	A61B-005	222	Measurements for diagnostic purposes (radiodiagnosis in A61B6/00; ultrasonic, sonic, or infrasonic diagnosis in A61B8/00); human identification.
7	G06Q-050	191	Systems or methods specifically suitable for particular business sectors, such as utilities or tourism (medical informatics in G16H) [2006.01, 2012.01].
8	G16H-020	186	ICT specifically suitable for treatment or health improvement plans, such as for processing prescriptions, guiding treatment, or monitoring patient adherence to medical advice [2018.01].
9	H04L-029	168	Devices, equipment, circuits, and systems not included in single groups from H04L1/00 to H04L27/00.
10	G06F-016	166	Information retrieval; database structures; file system structures [2019.01].

popular technology group areas with the highest number of patent applications. Additionally, based on the patent IPC classification and corresponding technical field cross-reference relationships published by the World Intellectual Property Organization, blockchain technology applications in the medical and health field are primarily focused on the following two technical areas: (1) Electrical Engineering: such as digital communication (H04L), computer technology (G06F), and information technology management methods (G06Q); (2) Instrumentation: such as medical technology (G16H, A61B) [10]. **Table 2** presents the details.

3.5. Co-occurrence analysis of IPC main groups based on social network analysis

After cleaning and analyzing the 1,927 sample patents included, it was found that 83.0% of the data from 1,887 sample patents contained valid IPC main group data, meaning that 1,567 sample patents simultaneously included more than one IPC main group data. A visual analysis of the co-occurrence network was conducted on the IPC main groups belonging to the 1,887 sample patents. The results indicated close cooperation among the IPC main groups. A cooperation network diagram was drawn for data with IPC co-occurrences exceeding 15 times, showing 44 IPC main groups represented by 44 nodes in the diagram. The size of each node was displayed according to the degree centrality value of the node, as shown in **Figure 5**.

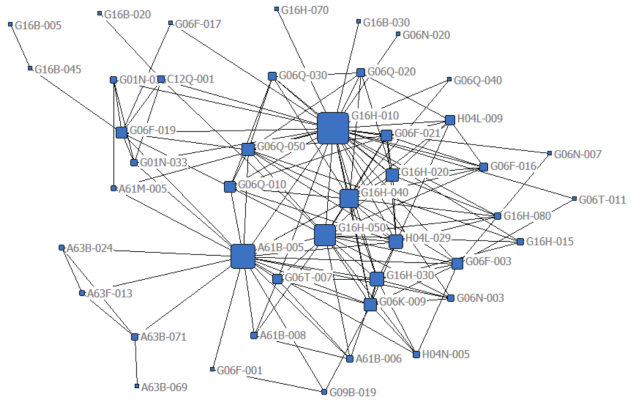

Figure 5. IPC main group co-occurrence network of blockchain patents in the medical and health information field

Further calculation of the degree centrality of the IPC main groups for the sample patents was performed, and the top 10 IPC main groups with the highest degree centrality were listed in descending order (**Table 3**). Among the top five IPC technical main groups with the highest patent application volume, apart from G06F-019, the other four groups had a relatively high degree of centrality, with G16H-010 ranking first in both lists. However, two technical fields with higher degree of centrality (G06K-009 and G06F-003) did not rank among the top 10 in patent application volume.

Table 3. Top 10 degree of centrality rankings of IPC main group co-occurrence network for blockchain patents in the medical and health information field

Ranking	IPC main group	Absolute degree centrality	Relative degree centrality
1	G16H-010	1946	3.816
2	A61B-005	1076	2.110
3	G16H-050	1076	2.110
4	G16H-040	901	1.767
5	H04L-029	734	1.439
6	G06K-009	665	1.304
7	G06Q-050	663	1.300
8	G06F-021	656	1.286
9	G16H-020	613	1.202
10	G06F-003	604	1.184

4. Discussion

Blockchain technology stores data in a blockchain structure, enabling a new computational paradigm and collaboration mode for establishing trust at lower costs. It has gradually established its own application scenarios and operational rules in the medical and health information field, becoming a research hotspot in this area. This study analyzed global blockchain patent data in the medical and health information field, revealing that the current patent application trends and technology lifecycle in this domain are in a rapid growth phase. The analysis of technology disclosure countries or organizations for the sampled patents showed that the top-ranked countries maintain a policy of actively supporting blockchain technology. For instance, in China's "13th Five-Year"

National Information Technology Plan released in 2016, blockchain technology was identified as a cutting-edge and hotspot technology deserving significant attention. To seize opportunities in the information technology field of the new era, the plan explicitly proposes strengthening the exploration and innovation of emerging technological directions, including blockchain [11].

The results of this study indicate that blockchain patent technologies in the medical and health information field primarily originate from their respective countries or organizations, suggesting a strong sense of protection for domestic markets among countries. Through patent layout strategies, active deployments are made in domestic and international medical blockchain markets, but policies vary. For example, patent layouts of various institutions in the United States are widespread, with blockchain-related patents applied not only domestically but also internationally as part of a global strategy. Germany also has a presence in multiple countries or regions globally. While the UK and Japan, with limited patent numbers, focus more on PCT patent applications. In contrast, countries like China, South Korea, and India primarily concentrate on domestic layouts, indicating a relatively weaker global patent presence compared to technological powers like the US and Germany. This difference might be associated with factors such as overall national technological strength and investment in medical resources. As blockchain technology is a fundamental technology, and the medical and health information field is a significant application level, Chinese institutions need to develop a stronger awareness of overseas layouts. Only through a combination of independent innovation and intellectual property protection can they enhance their core competitiveness in this domain [12-14].

This study also found that most of the major technology research and development institutions in this field are enterprises, accounting for 80% of the top 10 global institutions. These institutions primarily focus on providing solutions for various application scenarios using blockchain technology as the underlying framework. These scenarios include electronic health record systems, biosensor data processing, medical image recognition and diagnosis, dynamic monitoring of blood parameters, real-time dynamic clinical solution support, drug delivery and distribution systems, pharmaceutical research and development, health management, risk management, electronic prescriptions, biotechnology, and infectious disease tracing [15-17]. The patent application volume among the top-ranked institutions does not vary significantly, and several innovative enterprises, such as ENLITIC from the US and CATHWORKS from Israel, are included. This reflects that there is still a lack of dominant enterprises in blockchain technology, providing development opportunities for relevant institutions [18]. A further comparison of patent quantity and authorization rates between China and the US revealed that the US ranks higher in patent quantity, has an earlier start in this field, and has a higher patent authorization rate (27.2% vs. 9.2%).

Additionally, the application of blockchain technology in the medical and health information field has encompassed multiple technical classifications, including medical and health informatics, electronic digital data processing, transmission of digital information, diagnosis and identification, and methods for measuring or testing enzymes, nucleic acids, or microorganisms. From the perspective of social network analysis, there are currently differences between the highly collaborative technical areas and those with a larger number of early patent applications. Technical aspects such as data identification and representation, recording media and their processing, and transmission devices represent potential future patent layout points with significant development potential, requiring further collaboration across multiple technical fields.

5. Conclusion

In summary, this study discussed various perspectives of blockchain patent technology in the medical and health information field, including the overall patent application trend, technology lifecycle, regional distribution of technology research and development, distribution of technology research and development institutions, key areas of IPC technology research and development, and co-occurrence analysis of IPC main groups based on social network analysis. The findings suggest seizing the opportunity of rapid technological development, enhancing global layout awareness among relevant institutions, accelerating research and development paces for domestic enterprises, and promoting collaboration across multiple technical fields.

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Disclosure statement

The authors declare no conflict of interest.

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