

Research on the Development of Patents in Key Fields of the Automotive Industry in Huangpu District

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ABSTRACT

Against the backdrop of the global automotive industry's transformation towards "electrification, intelligence, connectivity, and sharing" (the "New Four Modernizations"), patents have become a core indicator for measuring the technological innovation capability of the industry. This study takes the automotive industry in Huangpu District as the research object. It first sorts out the macro-development trend of patents in China's automotive "New Four Modernizations" field, then focuses on three key areas of Huangpu District: power batteries, charging systems, and intelligent perception. Through the analysis of patent quantity, type, technological layout, and enterprise entities, the study reveals the advantages and shortcomings of Huangpu District's patent development. The research finds that Huangpu District has formed characteristics in battery swapping technology and basic research and development of intelligent perception, but there are problems such as insufficient layout of segmented technologies in power batteries and unbalanced structure of charging technologies. Finally, combined with industry trends, strategies such as targeted R&D, technological collaboration, and forward-looking layout are proposed to provide reference for Huangpu District's automotive industry to enhance its patent competitiveness.

KEYWORDS

Automotive Industry; Patent Development; New Four Modernizations; Power Batteries; Intelligent Perception

1. INTRODUCTION

Currently, the global automotive industry is undergoing a fundamental transformation centered on the "New Four Modernizations". Electrification breaks through energy constraints, intelligence reconstructs driving logic, and connectivity breaks down information barriers. Together, these three drive the industry's transformation from "vehicle manufacturing" to "intelligent mobile space services". As a statutory carrier of technological innovation, the depth and quality of patent layout directly determine the right to speak of the regional industry in global competition.

Huangpu District is a core agglomeration area of Guangzhou's automotive industry. In 2022, the output value of the automotive industry reached 173.4 billion yuan, accounting for 27% of Guangzhou's total. It has gathered leading enterprises such as GAC Honda, XPeng Motors, DeepRoute.ai, and Aulton New Energy, forming a complete industrial chain of "vehicle manufacturing - core components - intelligent innovation". In this context, an in-depth analysis of the current situation of patent development in key fields of Huangpu District's automotive industry can not only clarify the shortcomings of regional technological innovation but also provide a precise path

for it to align with the "New Four Modernizations" trend and achieve high-quality industrial development, which has important theoretical and practical significance.

2. MACRO TREND OF PATENT DEVELOPMENT IN THE "NEW FOUR MODERNIZATIONS" OF THE AUTOMOTIVE INDUSTRY

2.1. Patent Layout Trend of the "New Four Modernizations"

From 2013 to 2022, patents in China's automotive "New Four Modernizations" field showed differentiated development characteristics: electrification and intelligence continued to take the lead, connectivity rose first and then stabilized, and sharing gradually became marginalized. As can be seen from Table 1, the number of patent applications for electrification increased from 8,922 in 2013 to 43,487 in 2022, with an average annual growth rate of over 18%, always maintaining a core position in the industry; the number of patents for intelligence caught up with the development pace of electrification in 2019 (16,879) and reached 27,070 in 2022, becoming the second growth curve. The number of patents for connectivity reached a peak of 19,606 in 2021 and then dropped to 17,258 in 2022, reflecting that the technological layout has entered an adjustment period; due to problems such as inconvenience in use and high maintenance costs, the number of patent applications for sharing decreased from 487 in 2019 to 170 in 2022, gradually withdrawing from the core track [1].

Table 1. Number of Patent Applications in China's Automotive "New Four Modernizations" Fields from 2013 to 2022 (Unit: Piece)

Field	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Electrification	8,922	9,735	12,757	19,197	25,068	26,382	28,823	29,738	36,210	43,487
Intelligence	2,440	2,802	4,128	6,104	8,553	12,699	16,879	17,636	22,967	27,070
Connectivity	2,222	2,324	3,352	5,063	6,019	8,912	12,154	14,987	19,606	17,258
Sharing	20	32	67	186	281	335	487	380	350	170

2.2. Main Competitive Pattern of the "New Four Modernizations"

From the perspective of the distribution of patent applicants, domestic enterprises occupy a dominant position in all fields of the "New Four Modernizations", and different fields show characteristics of differentiated competitive entities (see Table 2):

Electrification Field: New energy vehicle companies have become the core force. BYD (5,469 pieces), CATL (5,384 pieces), and Toyota (5,772 pieces) are among the top 10. The number of patent applications by new energy vehicle companies accounts for 52% of the total of the top 10, surpassing traditional vehicle companies.

Intelligence Field: Technology companies and component enterprises take the lead. Huawei (2,206 pieces), Baidu Online (2,065 pieces), and Bosch (2,293 pieces) rank among the top three, highlighting the technical discourse power of technology companies under the trend of "software-defined vehicles" [2].

Connectivity Field: Communication enterprises dominate the technological layout. Huawei has 5,701 patents, far exceeding Qualcomm (3,371 pieces) in the second place, followed by enterprises such as OPPO (2,405 pieces) and Samsung (1,552 pieces), reflecting the supporting role of 5G technology in the Internet of Vehicles.

Sharing Field: Travel service enterprises focus on layout. Toyota (209 pieces), Didi (167 pieces), and Xuanyuexing (137 pieces) are the main applicants, but the overall number of patents is low, and the industrial popularity continues to decline [3].

Table 2. Top 10 Applicants for Patents in the "New Four Modernizations" Fields of the Automotive Industry (Unit: Piece)

Field	Top 10 Applicants (Ranked by the Number of Applications)
Electrification	Toyota (5,772), BYD (5,469), CATL (5,384), Beijing New Energy (3,109), Gotion High-Tech (2,845), Geely (2,808), Hyundai (2,715), Ford (2,523), Bosch (2,521), SVOLT Energy (2,471)
Intelligence	Bosch (2,293), Huawei (2,206), Baidu Online (2,065), Toyota (2,063), Changan (1,930), Honda (1,763), Ford (1,591), FAW (1,515), Tencent (1,420), Geely (1,253)
Connectivity	Huawei (5,701), Qualcomm (3,371), OPPO (2,405), Toyota (1,817), Samsung (1,552), VIVO (1,544), Ford (1,163), Tencent (1,150), Xiaomi (1,112), Changan (1,110)
Sharing	Toyota (209), Didi (167), Xuanyuexing (137), Geely (84), Honda (83), Leading Technology (74), Uxin Technology (63), Launch Tech (61), Ford (57), Chenqi Travel (55)

3. ANALYSIS OF THE CURRENT SITUATION OF PATENTS IN KEY FIELDS OF THE AUTOMOTIVE INDUSTRY IN HUANGPU DISTRICT

3.1. Power Battery Field

Power batteries are core components of new energy vehicles, accounting for nearly 50% of the total electrification patents (49.18% in 2022). The total number of patents in this field in Huangpu District exceeds 1,000, and the types of patents show a "balanced" characteristic: 521 invention patents (49.8%) and 525 utility model patents (50.2%), reflecting the simultaneous advancement of technological R&D and application transformation.

From the perspective of technological layout, Huangpu District focuses on two directions: First, battery systems and structures, conducting R&D around the lightweight of battery packs and the optimization of thermal management to solve the pain points of cruising range and safety; second, battery management systems (BMS), improving battery charging and discharging efficiency and service life through algorithm optimization, with Aulton New Energy Automotive Technology Co., Ltd [4]. as the representative enterprise. However, there are obvious shortcomings: there is less layout in the field of energy storage technology, and it has not followed up on emerging directions such as sodium-ion batteries. From 2021 to 2022, the number of national sodium-ion battery patents soared from 132 to 1,007, while patents related to Huangpu District are almost blank, facing the risks of lithium resource dependence and technological iteration.

3.2. Charging System Field

The charging system is a key support for the popularization of new energy vehicles, accounting for 19.08% of electrification patents in 2022, mainly including four technological directions: conductive charging, battery swapping, wireless charging, and optical-storage-charging systems. The patents in this field in Huangpu District show the characteristic of "breakthrough at a single point":

Explosive Growth of Battery Swapping Technology: The number of patent applications reached 465 in 2022, far exceeding the cumulative total before 2021, with Aulton New Energy as the core driving entity. The enterprise proposed a "dual-carbon four-step plan", achieving the goals of "carbon reduction - carbon storage - carbon sequestration - carbon control" through the construction of battery swapping station networks, echelon utilization of batteries, vehicle-to-grid (V2G) and other models, forming a differentiated competitive advantage [5].

Lagging Conductive Charging Technology: As the national mainstream charging technology (5,324 patents in 2022), the annual number of related patents in Huangpu District is only 40-50, failing to form technological accumulation.

Late Start of Optical-Storage-Charging Systems: There were 136 national patents for optical-storage-charging systems in 2022. Although Huangpu District has made layouts, the number is very small, failing to align with the "new energy + energy storage" industry trend.

3.3. Intelligent Perception Field

Intelligent perception is the "eyes" of intelligent vehicles, accounting for 7%-11% of intelligent patents, mainly including basic perception components (lidar, millimeter-wave radar, etc.), image processing, traffic information recognition and other technologies. The patents in this field in Huangpu District show the characteristics of "enterprise-led and focusing on the core":

Concentrated Innovation Entities: With two enterprises, XPeng Autonomous Driving and DeepRoute.ai, as the core, the former focuses on the layout of image processing (34 patents) and basic perception components (32 patents), while the latter focuses on image processing technology (18 patents), forming an "algorithm + hardware" collaborative R&D model.

Wide Technological Coverage: Patents involve obstacle detection, driver state perception, multi-sensor fusion and other directions. The number of patents for basic perception components in 2022 increased by 213% compared with 2013, reflecting the improvement of technological maturity.

Obvious Shortcomings: There are relatively few patents in high-end fields such as lidar hardware R&D and multi-sensor fusion depth algorithms, relying on external supply chains, and the independent and controllable capability is insufficient.

4. PROBLEMS EXISTING IN THE PATENT DEVELOPMENT OF THE AUTOMOTIVE INDUSTRY IN HUANGPU DISTRICT

4.1. Incomplete Technological Coverage in Key Fields

In the power battery field, there is no layout of emerging technologies such as sodium-ion batteries and solid-state batteries, missing the technical window for lithium resource substitution and energy density improvement; in the charging system field, conductive charging technology lags behind the national level, and the layout of optical-storage-charging systems is insufficient, making it difficult to meet diversified charging needs; in the intelligent perception field, the R&D of hardware such as lidar is weak, restricting the overall competitiveness of intelligence [6].

4.2. Unbalanced Structure of Patent Technologies

On the one hand, in the power battery field, invention patents and utility model patents each account for half. Although it reflects "integration of R&D and application", the proportion of invention patents is lower than the national average level of the automotive industry (55%), and the originality of core technologies is insufficient; on the other hand, in the charging system field, there is excessive reliance on battery swapping technology, and the technical reserves of conductive and optical-storage-charging technologies are insufficient, resulting in the risk of "strong at a single point but weak overall".

4.3. Insufficient Collaborative Innovation Among Enterprises

Huangpu District has gathered vehicle enterprises (GAC Honda), new energy enterprises (Aulton New Energy), and intelligent innovation enterprises (XPeng Autonomous Driving), but there is little

patent collaboration among enterprises: vehicle enterprises and component enterprises have not formed a joint R&D mechanism, and the technical connection between intelligent innovation enterprises and traditional vehicle enterprises is not smooth, resulting in the failure of patent technologies to form an industrial chain synergy effect and restricting the overall innovation efficiency.

5. STRATEGIES AND FUTURE OUTLOOK FOR THE PATENT DEVELOPMENT OF THE AUTOMOTIVE INDUSTRY IN HUANGPU DISTRICT

5.1. Targeted Breakthroughs in Technological Shortcomings

Power Battery Field: Establish a "Sodium-Ion Battery R&D Center" in collaboration with universities (such as South China University of Technology) and scientific research institutions, focusing on tackling core technologies such as cathode materials and electrolyte systems to fill the patent gap; promote cooperation between Aulton New Energy and CATL to lay out energy storage technology patents and realize the two-way development of "power batteries - energy storage".

Charging System Field: Rely on enterprises such as GAC Honda and XPeng Motors to strengthen the R&D of fast-charging technology for conductive charging and improve the quantity and quality of patents; introduce policies to encourage the construction of optical-storage-charging systems, support enterprises to apply for patents for integrated optical-storage-charging systems, and align with the "dual-carbon" goals.

Intelligent Perception Field: Support XPeng Autonomous Driving and DeepRoute.ai to cooperate with lidar enterprises (such as Hesai Technology) to jointly apply for patents for lidar hardware and multi-sensor fusion algorithms, and improve the independent and controllable capability.

5.2. Optimization of the Patent Technology Structure

Establish an "Invention Patent Incentive Fund" to provide a reward of 20,000-50,000 yuan for each invention patent obtained by enterprises in the fields of power batteries and intelligent perception, so as to enhance the originality of core technologies;

Guide enterprises to formulate a "patent portfolio strategy", form a layout of "core patents + peripheral patents" in the field of battery swapping technology, and build technical barriers; at the same time, supplement patents for conductive and optical-storage-charging technologies to achieve the balanced development of charging system technologies.

5.3. Construction of a Collaborative Innovation Platform

Led by the government, establish a "Huangpu District Automotive Industry Patent Collaboration Center" to integrate resources from vehicle enterprises, component enterprises, and universities, carry out joint R&D, and share patent achievements; promote the establishment of a "patent pool", include the battery swapping patents of Aulton New Energy and the intelligent perception patents of XPeng Motors into the pool, reduce the cost of enterprises' patent use, and promote technology diffusion.

5.4. Future Development Outlook

Combined with the national patent trend of the "New Four Modernizations", the patent development of Huangpu District's automotive industry will focus on three directions:

Electrification Field: Sodium-ion batteries, solid-state batteries, and optical-storage-charging systems will become hot spots for patent layout. Huangpu District needs to accelerate technological R&D to seize the initiative.

Intelligent Connectivity Field: Technologies such as artificial intelligence algorithms, domain controllers, and intelligent cockpits are the commanding heights of competition. Huangpu District should rely on the advantages of technology enterprises, strengthen the layout of related patents, and promote the integrated development of "intelligence + connectivity".

Chip Field: Drawing on the national model of "led by technology enterprises and joint ventures to reduce risks", support GAC and XPeng to cooperate with enterprises such as Huawei and Xiaomi to lay out automotive chip patents and solve the "chokepoint" problem.

6. CONCLUSION

By analyzing the macro trend of national automotive "New Four Modernizations" patents and the current situation of patents in key fields of Huangpu District, this study finds that Huangpu District has formed characteristic advantages in battery swapping technology and basic R&D of intelligent perception, but there are problems such as incomplete technology coverage, unbalanced patent structure, and insufficient enterprise collaboration. Against the background of the global automotive industry transformation, Huangpu District needs to enhance its patent competitiveness by making targeted breakthroughs in technological shortcomings, optimizing the patent structure, and building a collaborative platform to align with the development trends of electrification and intelligent connectivity.

In the future, with the improvement of patent layout in fields such as sodium-ion batteries, lidar, and automotive chips, Huangpu District is expected to form an automotive industry patent development pattern of "electrification as the foundation, intelligence as the leader, and connectivity as the enabler", providing core support for the high-quality development of the regional industry and at the same time providing "Huangpu Experience" for the national automotive industry patent layout.

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