2026 China Intelligent Robot Industry Outlook

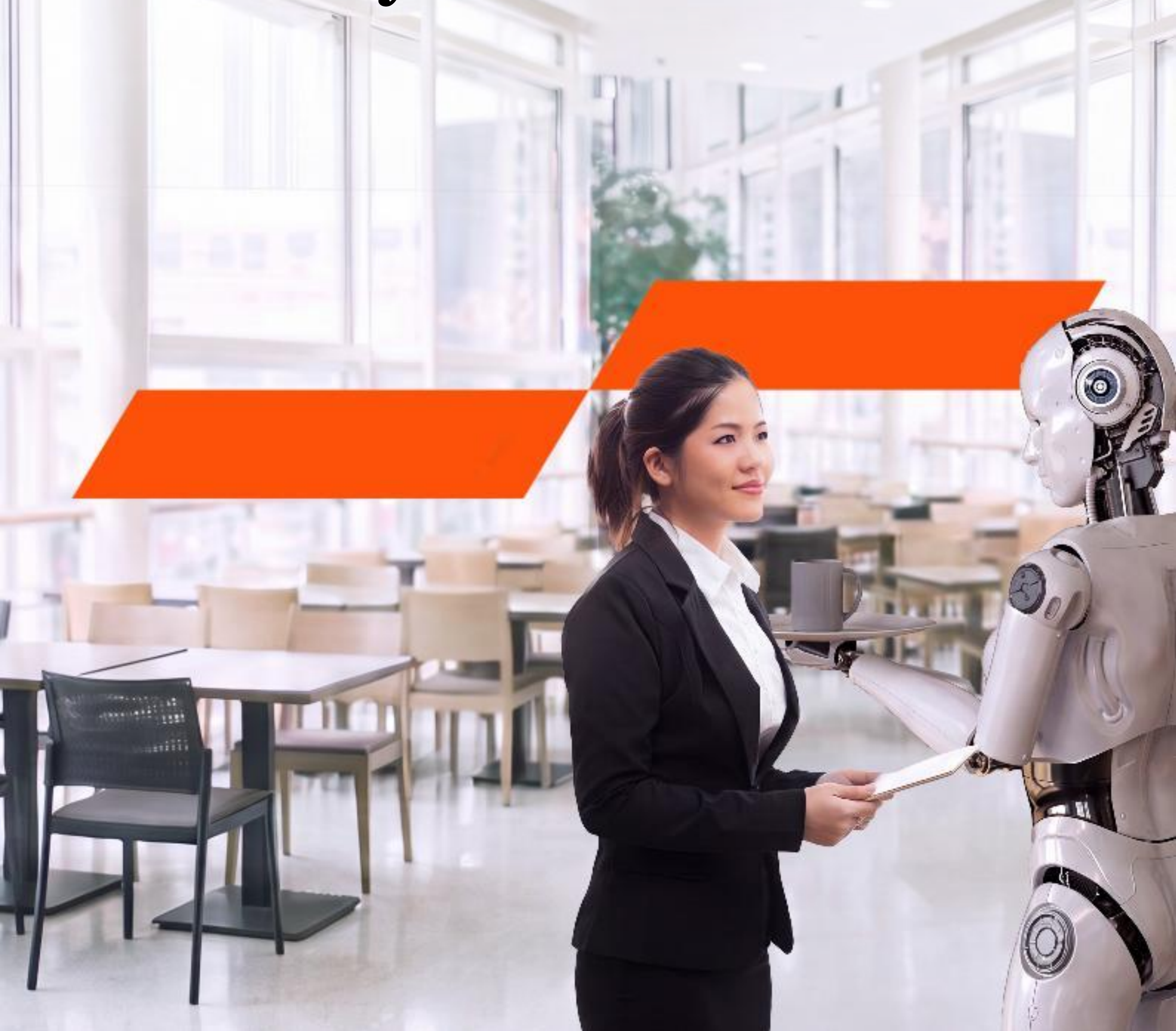


Table of contents

01

Report framework and core definitions

I. Report framework

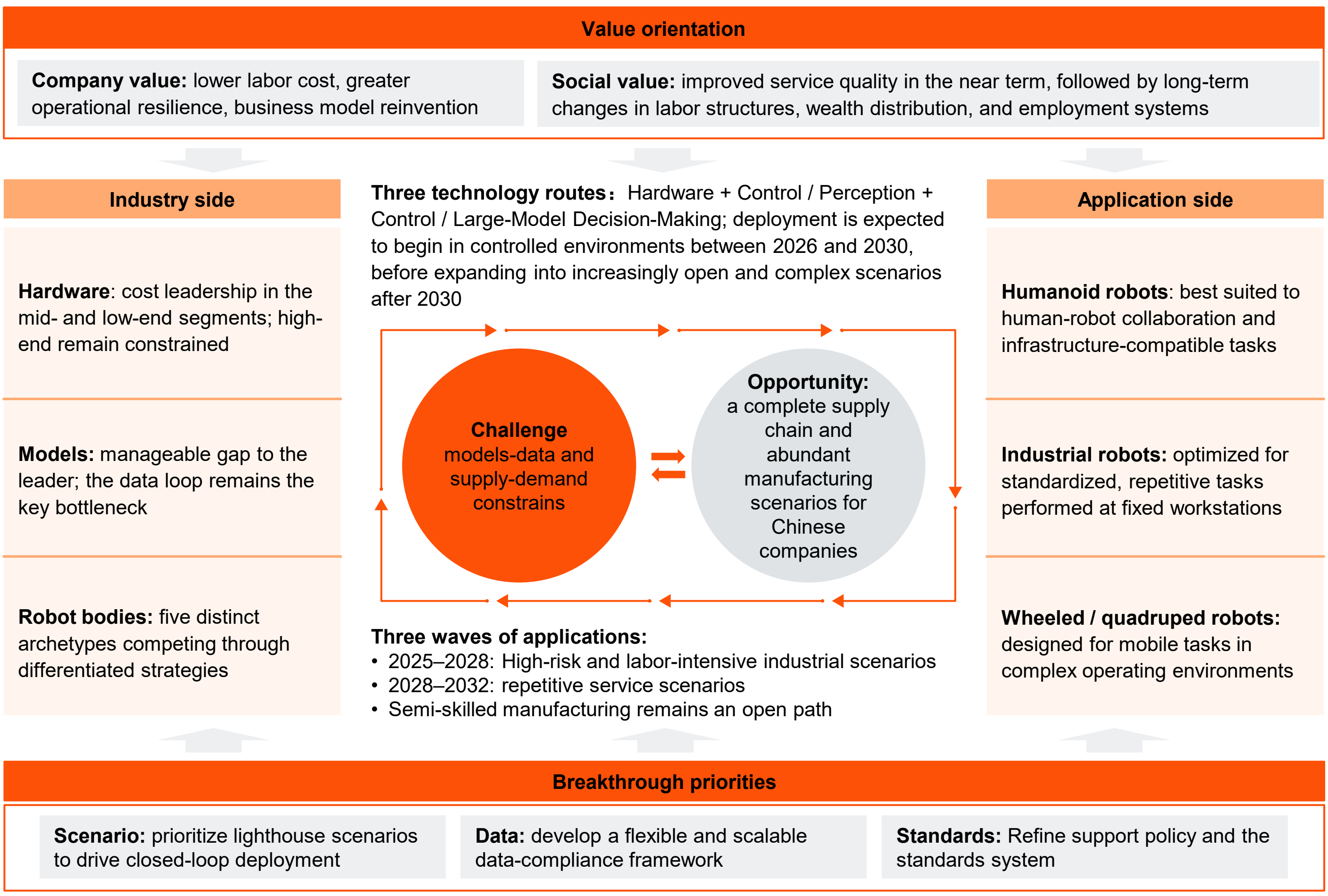
This report focuses on the development of China's intelligent robot industry by addressing three key questions: Where does the industry stand today? What value does it create? How can it achieve sustainable growth?

The report is structured around four dimensions: industry fundamentals of supply and demand, application scenarios, key opportunities and challenges, and the industry outlook. This comprehensive assessment provides insight into the industry's current position and long-term direction.

From an industry perspective, the analysis focuses on three core layers. In terms of competitiveness at the hardware layer, Chinese companies have demonstrated notable performance in the mid- and low-end segments. In contrast, the high-end market continues to be dominated by global incumbents. At the model layer, the industry's main bottleneck is establishing an effective data iteration loop. In the robot body layer, five distinct archetypes of market players have been identified. Each of these archetypes pursues a different competitive strategy.

From an application perspective, intelligent robot is developing around three primary product forms: industrial robots, wheeled and quadruped robots, and humanoid robots. Each of these forms is designed for specific use cases. Rather than evolving towards a single, overarching morphology, these product forms are expected to coexist over the long term, reflecting diverse technical requirements and economic trade-offs across use cases.

Report structure



Looking ahead, two structural constraints are expected to shape the industry's next phase of development. The first is the mutually reinforcing constraint between models and data, while the second is the interaction between supply and demand. At the same time, China possesses three enduring strategic advantages: a comprehensive manufacturing supply chain, sustained policy and capital support, and a broad base of industrial application scenarios. Collectively, these benefits establish a robust foundation for ongoing industry growth, promoting enhanced domestic substitution across the hardware stack while expediting the creation of scenario-specific AI models.

The report concludes with two forward-looking perspectives. The first reviews the evolution and eventual convergence of three technology pathways: Hardware + Control, Perception + Control, and Large-Model Decision-Making. The second outlines three successive waves of large-scale application adoption, illustrating how automation is expected to expand across application scenarios through 2030.

II. Core definitions

An intelligent robot is defined as an intelligent equipment system that integrates a new generation of intelligent technologies. It possesses four core capabilities: deep perception, intelligent decision-making, generalized interaction, and dexterous execution[1]. It is capable of adapting to complex scenarios and performing tasks autonomously. It serves as the core physical medium for intelligent manufacturing and intelligent services.

Intelligent robots are the primary physical carrier of embodied intelligence. Embodied intelligence is the idea that intelligence emerges from the dynamic interaction between an agent and its environment. Throughout this report, the term embodied intelligence is used in its industry-standard sense: a new generation of robotic technology systems with a closed perception–decision–action loop.

The four core capabilities are as follows.

Deep perception is the foundational capability that enables a robot to adapt to complex scenarios. The robot employs a multimodal sensing system to gather information about its environment and its own state through visual, auditory, tactile, and force detection. The result is precise cognition of complex scenarios, a substantial improvement in environmental adaptability, and a data foundation for downstream decision-making and execution.

Intelligent decision-making is the core nerve center of intelligent robot operation. Machine learning and intelligent algorithms process and analyze data using real-world data captured by the perception layer to predict trends. The robot is capable of outputting sound, efficient decision commands, and making autonomous judgments in complex, dynamic scenarios.

Generalized interaction is the key enabler of deployment across diverse scenarios. The robot utilizes speech recognition, image recognition, and affective computing to accurately interpret human needs and interaction intent, thereby facilitating natural human-machine interaction. It also interfaces with a range of smart devices and systems to perform cross-terminal, cross-system collaboration and to extend the boundaries of scenario application.

Dexterous execution is the final execution layer through which robot applications are delivered. The robot's operation is guided by intelligent decision commands and supported by dynamics models and high-precision control algorithms, enabling it to perform grasping, transfer, manipulation, and other complex tasks with flexibility. It is able to adapt its execution strategy to the scenario, ensuring the efficiency and stability of task delivery.

1. China Academy of Information and Communications Technology (CAICT); Alliance of Industrial Internet. White Paper on the Technology and Industry Development of Intelligent Robots (2023 Edition). 2023.

Delivering these four core capabilities necessitates an integrated technology architecture comprising four interconnected layers, which collectively establish a complete Perception–Decision–Action closed loop.

Perception layer	The perception layer encompasses machine vision and multimodal sensing technologies, such as inertial measurement units (IMUs), force and tactile sensors, and depth cameras, along with related devices. It is responsible for capturing raw environmental information, extracting low-level features, and generating structured representations of the operating environment. These real-time multimodal inputs provide the data foundation for downstream intelligence in the model layer.
Model layer	The model layer functions as the cognitive core of the intelligent robot system. The product is built around embodied foundation models, integrating three complementary capabilities: cognitive planning, perception-action mapping, and motion generation. Cognitive planning, enabled by vision-language models (VLMs), supports natural language understanding and high-level task decomposition. Perception-action mapping, driven by vision-language-action (VLA) models, translates multimodal sensory inputs into executable action sequences through end-to-end reasoning. Motion generation leverages diffusion-policy models and world models to optimize motion trajectories and predict physical interactions. The model layer is strategically positioned between perception and control, facilitating the transformation of environmental understanding into intelligent decision-making. It faciliates autonomous cognition and closed-loop operation in open physical environments.
Control layer	The control layer translates high-level decisions into precise physical execution through motion control algorithms and servo drive technologies. It converts action sequences generated by the model layer into joint torque and motion trajectory commands. It continuously monitors execution through real-time force feedback to ensure motion accuracy, operational stability, and system safety.
Hardware layer	Hardware layer provides the physical foundation of the entire system. It encompasses both robot platforms, including humanoid, wheeled, and quadruped robots, and key components such as reducers, servo motors, lead screws, and related hardware. Beyond supporting perception, computation, and actuation, the hardware layer continuously feeds physical-state information back to the upper layers through embedded sensing technologies, enabling closed-loop operation across the entire system.

02

China intelligent robot industry analysis

I. Industry analysis

1. Hardware layer: cost leadership in the mid- and low-end segments; high-end remain constrained

China's robotics hardware industry has established a strong competitive position in the mid- and low-end segments. This is due to the mature manufacturing ecosystem and large-scale mass-production capabilities that the industry has developed. In contrast, the high-end component market is predominantly influenced by international suppliers.

Chinese manufacturers have achieved notable competitiveness across several mid- and low-end component categories, where localization has significantly reduced costs.

- **LiDAR:** Chinese manufacturers such as RoboSense and Hesai have achieved performance comparable to leading international brands in sensing accuracy and detection range, while offering products at 30–50% lower cost. Both companies have achieved the distinction of being among the world's leading suppliers by market share.
- **Harmonic reducers:** Domestic companies, led by Leaderdrive, have increased China's localization rate to over 75%, driving average annual cost reductions of more than 16% across the industry.
- **Servo motors and six-axis force sensors:** Leading companies such as Inovance and Keli Sensing have initiated large-scale commercial deployment, enhancing domestic supply chains while reducing procurement costs and dependence on international suppliers.

The high-end component segment is an exception, where international suppliers maintain a dominant position.

- **Planetary roller screws:** Japanese and European manufacturers account for approximately 70% of the global market, led by companies including NSK, THK, Bosch Rexroth, and Schaeffler. Domestic suppliers continue to face challenges in product variety, manufacturing consistency, and application breadth.
- **High-end coreless DC motors:** The market continues to be dominated by FAULHABER and Maxon. Domestic products have yet to reach the performance levels of international leaders in key areas, including torque density, speed precision, size optimization, and durability. This limitation restricts their adoption in premium robotics and high-precision medical equipment.

2. Model layer: manageable gap to the leader; the data loop remains the key bottleneck

The competitive landscape for embodied-intelligence models is driven less by differences in algorithmic architecture than by differences in data accumulation, scenario coverage, and model iteration capability. While the United States currently maintains a leading position, China has the opportunity to narrow the gap by leveraging its unique strengths in manufacturing data and industrial applications.

Leading U.S. companies have established competitive advantages through vertically integrated development of embodied-intelligence models. Leading companies such as Tesla and Figure have developed closed-loop systems that span real-world data collection, annotation, model training, deployment, and continuous iteration. Tesla further benefits from technologies developed for autonomous driving, including data perception, sensor fusion, and scenario extraction. These technologies facilitate continuous advancements in robot intelligence and generalization through the analysis of large-scale operational data.

However, China possesses a structural advantage that few countries can replicate: the world's largest and most comprehensive manufacturing ecosystem. High-frequency, standardized production environments across automotive manufacturing, electronics, logistics, and warehousing continuously generate large volumes of real-world operational data, providing an exceptional foundation for developing vertically specialized models. In the long term, competitive differentiation is therefore unlikely to depend on which robot morphology ultimately prevails. Instead, leadership will increasingly be determined by the ability to accumulate proprietary industry data, develop high-performing vertical models, and commercialize them at scale.

The industry's primary constraint is the absence of a standardized, large-scale framework for scenario data collection and model iteration. The current volume of data being processed is not sufficient, and the efficiency of the process is limited. This restricts the potential for further improvements in the generalizability of the model and the accuracy of the decisions made. These challenges are further compounded by a shortage of experienced AI algorithm talent, which slows progress toward breakthroughs at the model layer.

3. Body layer: five distinct archetypes competing through differentiated strategies

The global robotics hardware sector is experiencing heightened engagement from players across various sectors, thereby reshaping the competitive landscape. Robotics start-ups are leading the commercialization and mass production of humanoid robots, while established robotics specialists continue to set the industry's technical standard through their extensive technological expertise. Traditional industrial automation companies are expanding into robotics by leveraging their strengths in core components and manufacturing capabilities. Concurrently, automotive and internet companies are injecting new momentum from two complementary directions: automotive players contribute industrial-scale manufacturing capabilities, while internet companies bring advanced AI algorithms and computing resources.

The five archetypes and their representative players are as follows:

01

Robotics-native start-ups

Companies such as Unitree, AgiBot, Leju, and Galbot represent a new generation of robotics innovators. These companies have rapidly emerged as global leaders in humanoid robot production and delivery, supported by China's comprehensive manufacturing supply chain. In 2025, AgiBot and Unitree ranked among the world's largest suppliers of humanoid robots by shipment volume[2]. Their competitive advantages lie in rapid product iteration, cost-efficient engineering, and an early focus on commercial deployment. Other representative companies include Fourier Intelligence and EngineAI Robotics.

02

Deep-rooted robotics specialists

Companies such as UBTech, Sevence Robotics, Pudu Robotics, and Keenon Robotics have been early entrants in the robotics market and have developed significant technological expertise over time. UBTech has established a leading position in humanoid robotics, with deployments spanning industrial, commercial, and educational applications. The company is supported by one of the industry's most extensive patent portfolios.

03

Traditional industrial-robot and automation giants

Originally established in industrial automation, these companies have built deep expertise in servo systems, reducers, and other core components, along with strong capabilities in robot body manufacturing. They are leveraging their existing technological capabilities and customer relationships to expand into complete robot systems. In China, leading players such as Inovance and Estun are gaining momentum, fueled by the domestic substitution trend and their competitive advantages in the new energy sector.

05

Cross-over internet companies

Internet companies are participating in humanoid robotics primarily through their strengths in AI algorithms and computing infrastructure. Alibaba has introduced the Qwen-Robot series of embodied-intelligence large models, while Tencent's Robotics X Lab focuses on multimodal perception and dexterous manipulation. These companies are strategically positioning themselves at the algorithm and platform layers of the robotics value chain, leveraging their strengths in AI foundation models and computing power.

04

Cross-over technology and automotive players

Automakers are entering the humanoid robotics market for three key reasons: technological synergies with the automotive industry, the reuse of manufacturing capabilities, and application opportunities within automotive production. Leading intelligent-driving companies have developed integrated capabilities that span data perception, sensor fusion, scenario extraction, and software-hardware integration. These capabilities position them as versatile players in the cross-sector transfer of both AI models and hardware capabilities into robotics. In China, more than ten automotive companies, including GAC, SAIC, BYD, Xpeng, Chery, and Xiaomi, together with supply chain players such as Huawei and Horizon Robotics, have entered the humanoid robotics market.

2. Omdia Market Radar: General purpose Embodied Intelligent Robots, 2026.

II. Application scenario analysis

1. Three mainstream scenarios: industrial, service, and specialized

As intelligent technologies continue to advance and demand from the real economy expands, intelligent robots are being deployed across a more diverse range of applications, while technology convergence continues to accelerate. The industry is entering a new phase characterized by large-scale deployment and greater application diversity. According to the national standard Classification of Robots (GB/T 39405-2020), robots are classified into three major application categories: industrial robots, service robots, and specialized robots[3]. Collectively, these categories represent the current mainstream of intelligent robot applications.

Industrial robots

Industrial robots are utilized in a variety of applications, including material handling, machine tending, welding, painting, precision machining, assembly, and cleanroom operations.

Service robots

The market for service robots is segmented into two primary categories: personal/household service robots and public service robots. Household service applications include housework, education, entertainment, elderly and disabled care, and home security. Public service applications include catering, guidance and interpretation, multimedia services, public entertainment, and personal mobility.

Specialized robots

These robots are designed for professional and mission-critical applications. Such applications include equipment inspection and maintenance, industrial testing, search and rescue, reconnaissance, explosive ordnance disposal, engineering installation, mining and haulage, surgery, and rehabilitation assistance. These robots are typically deployed first in environments that are hazardous or unsuitable for human workers, making them the leading solution for the intelligent automation of high-risk operations.

3. CAICT; Alliance of Industrial Internet. White Paper on the Technology and Industry Development of Intelligent Robots (2023 Edition). 2023.

In terms of deployment scale, the International Federation of Robotics (IFR) reported that global installations of industrial robots reached 542,000 units[4] in 2024 and installation of professional service robots reached 199,000 units in the same year[5].

Intelligent upgrading has become the defining trend of the robotics industry. The IFR identifies artificial intelligence as the industry's most significant technology trend, emphasizing how analytical AI, physical AI, and generative AI are transforming robots' perception, decision-making, and execution capabilities[6]. Analysis by the China Academy of Information and Communications Technology (CAICT) based on 88 representative global use cases further corroborates this trend. AI-powered machine vision has been adopted in 22% of quality management applications, while perception-and-navigation solutions account for 25% of logistics and distribution scenarios. Meanwhile, the integration of foundation models and reinforcement learning is expediting the evolution of industrial robots from conventional automation to higher levels of intelligence. Consequently, the seamless integration of algorithms and data is emerging as a pivotal competitive differentiator in the industry[7].

2. Three product forms addressing differentiated scenarios

Scenario demands continue to influence the evolution of robot form factors. The intelligent robot market is currently dominated by three primary product categories: specialized robots, wheeled and quadruped robots, and humanoid robots. After years of commercial deployment, these three forms have established differentiated roles across application scenarios, a structure expected to remain largely stable through 2030.

Specialized robots, such as industrial robotic arms, are designed for standardized operations at fixed workstations. These products are known for their exceptional precision, strong stability, and high adaptability. They are deeply embedded in advanced manufacturing applications such as machine tending, welding, painting, and precision assembly, serving as a core foundation for manufacturing automation upgrades.

Wheeled / quadruped robots are engineered for optimal performance in mobile scenarios, supporting applications such as transportation, inspection, and material handling. Their efficient mobility, strong adaptability to complex environments, and stable operating performance have enabled large-scale commercial deployment across food delivery, warehousing and logistics, industrial inspection, retail services, and pharmaceutical distribution.

4. International Federation of Robotics. World Robotics 2025 – Industrial Robots. 2025.
5. International Federation of Robotics. World Robotics 2025 – Service Robots[R]. 2025.
6. International Federation of Robotics. Top 5 Global Robotics Trends 2025. 2025
7. CAICT Jiangsu Institute; Suzhou Robot Industry Association. "Robotics + AI" Industrial Application Research Report. 2025.

Humanoid robots are designed primarily for human-robot collaboration and scenarios that require compatibility with existing human-built environments. Their human-like form enables direct interaction with workplaces, tools, and equipment designed for people, making them well suited to applications such as flexible manufacturing assembly, hospital care, household services, and elderly companionship. Their greatest value lies in scenarios where existing human infrastructure and operating processes can be reused. However, when a human-like form is not essential, humanoid robots may not always provide a cost-effective, energy-efficient, or reliable solution.

Over the next three to four years, the development of different robot forms will be shaped by both technological maturity and application adaptability. According to IDC, the adoption of wheeled and quadruped robots is projected to increase rapidly in indoor and semi-structured environments, supported by their proven stability and adaptability. These robots are expected to achieve a projected CAGR of up to 120% by 2030. Full-size bipedal humanoid robots are projected to grow at a CAGR exceeding 95%, reflecting their potential to perform a broader range of flexible tasks. Industrial robotic arms are expected to maintain steady growth while continuing to serve as the cornerstone of manufacturing automation[8 9].

8. IDC. Worldwide Annual Humanoid Robotics Tracker.2026.
9. IDC. 具身智能与人形机器人:中国工业落地新机遇, 2026.

3. Value and limitations coexist

In recent years, humanoid robots have emerged as a pivotal sector of interest within the industry. Their core strength lies in their inherent compatibility with physical environments designed around people. Workbenches, tools, corridors, and shelving systems all reflect human body structures and movement patterns. Consequently, humanoid robots can operate directly within existing infrastructure and utilize tools already designed for human workers, reducing deployment barriers while creating significant potential for scenario expansion[10 11].

At the same time, humanoid robots continue to face two fundamental constraints—cost and technology—which remain the key bottlenecks to large-scale commercialization.

On the cost side, the unit cost of a humanoid robot remained between USD 30,000 and USD 75,000 in 2025. Given that manufacturing investments generally require a payback period of approximately two years, unit costs would need to decline to around USD 15,000 while achieving productivity comparable to human labor before large-scale adoption becomes economically viable[12]. Bank of America estimates that sustained progress in key areas, coupled with enhanced production capacity, has the potential to reduce unit costs to approximately USD 15,000–17,500 between 2030 and 2035[13].

On the technology side, the Embodied Intelligence Development Report (2025), a joint study by the CAICT and the Department of Electronic Engineering at Tsinghua University, identifies shortcoming in current humanoid robots. Specifically, the report indicates that these robots currently lack the precision and reliability necessary for industrial applications and the practical performance required for service scenarios. There is a particular need for further validation of the reliability of bipedal hardware platforms, energy efficiency, and safe human-robot interaction technologies. Before 2030, three critical technological challenges must be addressed: dynamic balance control for bipedal locomotion, high-precision force sensing, and robust multimodal sensor fusion. Concurrently, robots must continue to enhance their generalizability capabilities to enable more effective autonomous decision-making in complex environments and unfamiliar tasks.

10. Tongji University National Institute of Innovation and Development. Are Humanoids the Optimal Solution for Robots? 2026.
11. Alex Greenberg, Siemens Digital Industries Software. Humanoids on the Factory Floor: The Next Frontier of Automation. Advanced Manufacturing, 2025.
12. Guotai Haitong Securities. In-Depth Research on the Embodied-Intelligence Industry (VII): A New Generation of “Blue-Collar” — How Humanoid Robots Stand on the Factory Line. 2025.
13. Bank of America. Humanoid robots 101. 2025.

III. Opportunities and challenges

PwC believes that, over the next three to four years, no single humanoid form factor will be capable of meeting the full range of operational requirements across application scenarios. Overinvestment in humanoid robots alone could therefore result in inefficient resource allocation and distort the industry's long-term development. By 2030, the intelligent robot industry is expected to evolve toward a landscape characterized by diversified robot form factors, scenario-specific deployment, and complementary technologies. Humanoid robots will deliver the greatest value in selected flexible applications, while industrial robotic arms and wheeled/quadruped robots will continue to strengthen their positions in their respective core scenarios. It is anticipated that these three product forms will coexist and complement one another over the long term.

1. The dual constraint: model-data bottlenecks and supply-demand imbalance

China's intelligent robot industry which is currently undergoing a critical phase of technological iteration and commercialization. The industry's primary challenge is no longer a single technological or hardware constraint, but rather a dual bottleneck comprising the model-data loop and the supply-demand dynamic. Consequently, these constraints are impeding progress in technology iteration, hardware cost reduction, regulatory readiness, and large-scale commercialization.

From the model-data perspective, the industry has yet to reach a consensus around a general-purpose foundation model. The presence of multiple technology pathways has led to a fragmentation of data requirements across various application scenarios, resulting in consistently high data acquisition costs. High-quality real-world data collected through conventional teleoperation still costs more than USD 1 per data point. Despite the ongoing innovation in the industry, which has led to a reduction in the average cost to around USD 0.5 per data point, high-quality interaction data suitable for model training remains limited.

Industry estimates indicate that developing a high-performance embodied AI model necessitates a minimum of ten million hours of training data. However, currently available embodied-intelligence datasets total only a few hundred thousand hours, which is approximately two orders of magnitude below the required scale. In contrast, leading commercial service robot companies have accumulated navigation and manipulation data spanning tens of millions of operating hours through large-scale deployment and high-frequency operation. These real-world operational datasets are becoming a critical strategic asset for building data advantages and accelerating the commercialization of embodied AI.

However, the available data is currently insufficient in terms of scale and consistency to support efficient model iteration. Conversely, uncertainty over future model architectures prevents data requirements from converging. This creates a self-reinforcing cycle in which fragmented technology pathways lead to fragmented data collection, slowing model iteration and further reinforcing technological divergence. This has become one of the industry's most fundamental structural constraints.

These constraints impact the industry supply side, constraining large-scale development in two ways. First, the fragmentation of technology pathways hinders the reduction of hardware cost. As multiple robot morphologies and technical architectures evolve in parallel, product specifications remain fragmented and core components lack standardized definitions. This prevents economies of scale from emerging. While domestic substitution has made meaningful progress in mid- and low-end components, key bottlenecks remain in high-precision reducers, dexterous hands, dedicated AI chips, and other high-end components. R&D investment in these technologies is challenging to amortize due to the lack of sufficient deployment scenarios at scale.

Secondly, the fragmentation of data requirements can lead to increased compliance costs. The diversity of scenario-specific data requirements has outpaced the evolution of existing regulatory frameworks. To support model development, companies must collect data across diverse operating environments. This has led to a notable increase in compliance complexity and operating costs, while also raising barriers to acquiring high-quality real-world data.

These supply-side constraints ultimately translate into application-side challenges, creating a two-way supply-demand imbalance that limits commercial adoption and large-scale deployment. On the demand side, high costs continue to influence purchasing decisions. Limited localization of key hardware, high data acquisition costs, and the absence of economies of scale have contributed to the high cost of robot prices. When considered in conjunction with the uncertainty surrounding investment returns and the shortage of maintenance talent, these factors have led to a decline in purchasing willingness among company and institutional customers. The limited deployment of the model hinders the accumulation of operational data, thereby preventing the model-data feedback loop from achieving scale.

At the same time, the progressive development of industry standards contributes to elevated deployment risk. Safety certification systems, quality standards, and liability frameworks have not yet kept pace with industry development. Although the Ministry of Industry and Information Technology (MIIT) released China's national humanoid robot standards framework in 2026 [14], scenario-specific technical standards and liability allocation mechanisms remain under development. The absence of clearly defined legal responsibilities and compensation mechanisms for human-robot interaction incidents complicates the quantification of deployment risks, further slowing adoption across commercial application scenarios.

2. Three strategic assets fuel future growth

China's intelligent robot industry benefits from three key strategic assets. First, it possesses the world's most comprehensive industrial supply chain, enabling rapid component development and iteration while lowering barriers to industry participation. Second, the sustained support from both policy and capital provides a strong foundation for long-term investment, rapid deployment, and industry development. Third, its extensive manufacturing base offers abundant application scenarios and data resources, creating favorable conditions for technological advancement and product commercialization.

Supported by these structural advantages, China's intelligent robot industry is expected to evolve across differentiated technology layers. Building on its mature engineering capabilities and large domestic market, the perception, control, and hardware layers will continue to advance domestic substitution. Segments that have already achieved technological breakthroughs are expected to shift their focus toward performance enhancement, cost optimization, and market-share expansion. Constrained organizations will prioritize breakthroughs in materials and manufacturing processes, with progressive progress expected over the next five to ten years. The model layer is likely to follow a differentiated development path. In the near term, the priority will be to develop vertical foundation models tailored to manufacturing applications, building competitive advantages in specific scenarios. Over time, continued improvements in data collection, annotation, and standardization, together with the cultivation of high-end talent and refinement of the model-data iteration loop, are expected to progressively bridge the gap with global leaders.

14. MIIT Humanoid Robot and Embodied Intelligence Standardization Technical Committee. Standard System for Humanoid Robots and Embodied Intelligence (2026 Edition). 2026.

03

China intelligent robot industry development pathways

I. Three technology routes evolving in parallel

The industry's technology landscape is defined by a four-layer technology architecture of intelligent robot. This architecture comprises the model, perception, control, and hardware layers. Given the technological positioning of domestic players and the current stage of industry development, three primary technology routes have emerged: Hardware + Control, Perception + Control, and Large-Model Decision-Making.

These three routes differ significantly in their sources of competitive advantage, commercialization maturity, and long-term potential. Looking ahead, each is expected to continue advancing along its own trajectory while gradually converging, collectively driving the industry toward higher levels of intelligence.

1. Core technology routes

Hardware + Control (Route A)	Proprietary hardware and motion-control technologies form the core competitive advantage. The fundamental performance of a robot, including its motion precision, operational stability, and force control, is determined by its hardware architecture and underlying control algorithms. This route emphasizes the development of essential hardware components, including motors, reducers, and sensors, while consistently enhancing motion control, sensor fusion, and real-time control algorithms. It signifies the fundamental technological trajectory of the robotics sector.
Perception + Control (Route B)	Real-time environmental perception and adaptive motion control are critical factors in maintaining competitiveness in the market. This approach is founded on the principle that autonomous operation across diverse scenarios is of greater importance than hardware specifications alone. The development of technology is centered on enhancing perception capabilities, such as SLAM navigation, multi-sensor fusion, and reinforcement learning. These advancements enable robots to perceive their surroundings, adapt to various scenarios, and execute tasks autonomously, reducing reliance on high-precision hardware.
Large-Model Decision-Making (Route C)	The industry's long-term direction is toward higher-order intelligence, powered by large models representing embodied intelligence. This route leverages the cognitive capabilities of large language models and multimodal models to facilitate natural-language understanding, complex task decomposition, and generalized execution across multiple scenarios. Its core competitive advantage lies in its intelligent decision-making capability, allowing robots to operate beyond the limitations of single-task, predefined applications.

2. Competitive landscape across technology routes

Hardware + Control currently serves as the foundation of China's intelligent robot sector. It offers a well-established commercialization model and sustainable long-term growth potential. Leading companies such as Inovance, Estun, and ROKAE have achieved scaled mass production and deployment while maintaining steady revenue growth. These domestic leaders are leveraging cost competitiveness and localized service capabilities to gain market share from international competitors and expand from low-end substitution into more demanding high-end applications.

Perception + Control currently offers the clearest commercialization pathway and has achieved the strongest deployment results. Companies including Pudu Robotics, Keenon, and Sevnce are prime examples of companies that have achieved commercial success in their respective application domains. Their competitive advantage stems from engineering capabilities accumulated through years of real-world deployment, with five to eight years of scenario experience creating a meaningful first-mover advantage. Looking ahead, this route is expected to face competitive pressure from both directions: hardware-driven players are continuing to strengthen intelligent capabilities, while large-model players are extending downward into application scenarios. In response, companies such as Pudu Robotics are expanding into large-model technologies to pursue greater technology integration.

Large-Model Decision-Making signifies the industry's long-term strategic direction, though it remains in the nascent stage of commercialization. Embodied intelligence, powered by large models, is a key investment theme in the industry, demonstrating significant long-term potential. However, the maturity of the technology has yet to match market expectations, and large-scale commercial deployment is unlikely before 2030. The current development model, which is based on scenario-specific customization and VLA-based deployment, is still in the early stages of exploration. Should more general-purpose approaches, such as world models, achieve major technological breakthroughs, the industry's competitive landscape could be fundamentally reshaped.

3. The convergence of technology routes

PwC believes the three technology routes will increasingly converge at both the company and product levels as application scenarios continue to evolve. Several leading companies have already begun adopting full-stack development strategies. Estun, a company with a background in Hardware + Control, has developed the ESTUN-CHAT AI language model and the CoDroid multimodal large model for industrial embodied intelligence. PaXini, representing the Perception + Control route, is pursuing a full-stack strategy spanning embodied perception hardware, tens of billions of multimodal real-world data samples, the OmniVTLA embodied intelligence model, and scenario deployment. Commercial service robot companies such as Pudu Robotics are also moving toward an integrated Perception + Control + Large-Model architecture, using a unified foundation model and software platform to support multiple robot form factors—an emerging "one brain, multiple forms" approach. The pace of convergence will largely depend on the maturity of large-model decision-making capabilities, and it is expected to unfold in two stages.

Near-term convergence (2026–2030): priority will be given to structured scenarios. During this period, technology convergence is expected to begin in structured environments characterized by limited variability, high precision, and well-defined operating conditions. Representative applications include semiconductor precision assembly, material handling, and logistics distribution. These scenarios feature controlled environments, standardized tasks, and moderate interaction requirements, making them well aligned with current technology maturity and the most suitable starting point for large-scale deployment.

Long-term convergence (post-2030): will involve expansion into open scenarios. In scenarios that are more open and dynamic, such as household care, robots require generalized intelligence, continuous autonomous interaction, and the capability for complex task decision-making. These applications impose significantly higher demands on technology integration, system reliability, and safety and regulatory frameworks. As these capabilities continue to evolve, deployment is expected to expand gradually beyond 2030, representing the long-term direction of industry development.

II. Three waves of demand driving large-scale adoption

1. Conditions for scaled adoption

The adoption of intelligent robots will be driven by a gradual and phased process, influenced by technology maturity, cost competitiveness, and scenario suitability. Successful deployment depends not only on integrating hardware with computing power, but also on establishing reliable autonomous operating processes tailored to specific application scenarios. The reliability of a system ultimately depends on the degree of engineering integration between software, hardware, and operating environments.

The rate of adoption will be determined by the dynamic balance between the value created by intelligent robots and the costs associated with their deployment. Value comprises both economic and social benefits, while costs include economic, risk-related, and broader social costs. The evolving balance between these factors will determine both the pace and extent of adoption across different application scenarios.

On the value side, intelligent robots contribute to the generation of economic value by engaging directly in production and service activities. Through continuous operation, data accumulation, and experience transfer, they improve operational efficiency and productivity. Their broader social value is equally significant and is reflected in three areas:

- **Occupational safety.** Replacing human workers in hazardous environments can significantly reduce workplace accidents and improve production safety.
- **Labor-force development.** intelligent robots are enabling workers to transition from "3D" jobs, which are characterized by dull, dirty, and dangerous tasks, to higher-value activities.
- **Service accessibility.** intelligent robots have the potential to address the shortage of high-quality labor in sectors such as healthcare and household services, thereby improving access to essential services.

On the cost side, the primary factor driving large-scale substitution is economic viability. Advancements in domestic production of core components have led to a significant reduction in robot costs. Following the localization of key components such as harmonic reducers, component prices have fallen to less than one-third of imported alternatives, reducing the cost of robot systems from approximately USD 150,000 to around USD 30,000. As the cost difference between robots and human labor continues to decrease, the economic argument for wider use grows stronger.

Risk-related costs are another important factor in determining sustainable adoption. These costs include both ongoing risk mitigation costs and compensation associated with operational incidents. As robot deployment expands, the global robot liability insurance market has grown rapidly, reaching USD 2.7 billion in 2024 and projected to increase to approximately USD 7.9 billion by 2033, representing a CAGR of 12.6%[15]. At the same time, incidents involving robot malfunctions, unintended injuries, and operational errors continue to occur, with high compensation costs increasing deployment risks across application scenarios.

Social costs represent a longer-term constraint on the scale and pace of robot adoption, primarily through their impact on employment structures. As robotics technology advances, a growing number of lower-skilled jobs are likely to be automated, requiring workforce transition, large-scale reskilling, and broader social adaptation. These challenges are especially relevant in labor-intensive service sectors, where concerns about employment adjustments are likely to temper the speed of widespread robot adoption.

15. Market Intel. Robotics Manufacturer Liability Insurance Market Research Report 2033. 2025.

2 The pace of large-scale adoption

As the balance between value and cost continues to evolve, the large-scale adoption of intelligent robots in China is expected to follow a clear wave-based trajectory, with significant differences in adoption timing and maturity across application scenarios. By 2030, a layered adoption landscape is expected to emerge.

Wave 1
2026-2028

intelligent robots achieve large-scale adoption first in high-risk, labor-intensive operations and standardized commercial service scenarios. In these applications, manual work is either hazardous and physically demanding or highly standardized with a clear economic return. This makes the safety and economic benefits of robot deployment compelling. Consequently, these scenarios have already crossed the threshold for large-scale adoption. The deployment of wheeled and quadruped robots at scale is projected to extend to a variety of applications, including factory and warehouse inspection, remote equipment operation and maintenance, and commercial services such as food delivery, hotel delivery, and building services. These deployments will improve operational efficiency and reduce workplace safety risks. As costs continue to decline and system reliability improves, robot penetration is expected to deepen further, with some scenarios approaching full automation.

Wave 2
2029-2032

intelligent robots are gradually being introduced into more complex and repetitive service scenarios. During this stage, robots are expected to extend into supermarkets, open retail environments, complex buildings, and hotel services. Their capacity to execute a growing array of standardized tasks will contribute to addressing persistent labor shortages and high employee turnover within the service sector. However, large-scale adoption will continue to be constrained by workforce transition costs, the absence of clearly defined liability frameworks for human-robot interaction, and the continued evolution of service standards. These scenarios also require stronger generalization capabilities, and long-term validation of operational stability and safety compliance is necessary before widespread adoption can be achieved.

Wave 3

The field of semi-skilled manufacturing represents a significant opportunity for the application of intelligent robots. Applications such as flexible assembly, precision inspection, and complex parts handling are expected to become key areas for deeper integration between robotics and advanced manufacturing. The pace of adoption will be contingent on breakthroughs in dexterous manipulation, cross-scenario generalization, and embodied AI foundation models. Once these technologies reach sufficient maturity, robots will become core production units within complex manufacturing processes. In the long term, continued advances in technology and cost competitiveness are expected to make semi-skilled manufacturing the next major engine of global manufacturing transformation.

04

Value of large-scale adoption

I. Creating economic value, strengthening resilience, and enabling business innovation

The large-scale deployment of intelligent robots has the potential to create value for companies across three dimensions: cost structure, operational resilience, and business model reinvention. This fundamental reshaping of production and operating systems will have a significant impact on the real economy.

Direct value: optimizing labor cost structures

While the initial investment for an intelligent robot often exceeds the annual cost of a single worker, its lifecycle economics provide a clear long-term benefit. For instance, a single unit of welding robots, including basic system integration, requires an investment of approximately USD 22,500–45,000. Assuming an eight-year depreciation period, the annual depreciation amount is estimated to be between USD 3,000 and 6,000. When including annual maintenance, energy consumption, and operator costs of USD 4,500–7,500, the total annual operating cost is approximately USD 7,500–12,000. This is well below the USD 18,000–22,000 annual employment cost of a skilled welder, including wages, social insurance, and benefits. In standard production environments, robots have already demonstrated a clear economic advantage, helping companies reduce long-term labor costs.

Implicit value: strengthening operational resilience

intelligent robots can help address many of the structural challenges associated with traditional labor, including recruitment difficulties, high employee turnover, uneven skill levels, and inconsistent operational performance. Consequently, they enhance production stability, ensure product quality consistency, and allow companies to respond more flexibly to market demand fluctuations. In the face of labor shortages and increasing labor costs, greater operational resilience and production flexibility are becoming essential for competitive advantage.

Emerging value: reinventing business models

The convergence of robotics and artificial intelligence is driving the development of innovative business models, such as lights-out factories, intelligent logistics, AI-assisted medical triage, and intelligent customer service. These innovations are reshaping traditional cost structures and operating models while accelerating the transition from labor-intensive production toward intelligence- and productivity-driven operations. In China, humanoid robots and select specialized robots have already adopted commercial models such as leasing, Robot-as-a-Service (RaaS), and Skill-as-a-Service, providing integrated solutions that combine general-purpose hardware with scenario-specific capabilities for applications including entertainment, R&D validation, and customized warehousing. As customization capabilities continue to evolve, business models are expected to evolve toward integrated offerings that combine scenario-specific AI models, general-purpose hardware, and cloud-based services.

II. Enhancing service experience and reshaping employment

The widespread adoption of intelligent robots will reshape society through a gradual and phased process. In the near term, the primary impact will be improvements in service quality and accessibility. In the medium to long term, robotics is expected to cause fundamental changes in labor markets, income distribution, and employment structures. These changes will reshape both everyday life and the nature of work.

Short term (2026–2031): improving service experience with limited employment disruption. Over the next five years, service robots for food delivery, logistics, and cleaning are expected to become increasingly common across commercial settings. Consumers will benefit directly from greater service efficiency, lower operating costs, faster response times, and greater convenience. During this stage, robot deployment will remain concentrated in manufacturing and entry-level service functions, with only a limited direct impact on overall employment.

Medium to long term (2032–2036): employment restructuring and increasing social adjustment. Beyond 2031, the implementation of intelligent robots is projected to extend to a wider range of labor-intensive industries. Lower-skilled occupations, such as logistics sorting, restaurant back-of-house operations, hotel housekeeping, and manufacturing assembly, are projected to experience increasing substitution pressure. This transition will coincide with structural changes in China's working-age population, amplifying the challenges associated with labor market adjustment.

At this stage, technological feasibility is expected to be largely established, while equipment costs will continue to decline. Social acceptance and policy readiness are the primary sources of uncertainty. Insufficient policy preparation could increase the risk of structural unemployment, whereas excessive intervention could slow technological progress and weaken manufacturing competitiveness. It is therefore incumbent upon policymakers to strike an appropriate balance between supporting technological innovation and managing its social impact.

Concurrently, the robotics era will be defined by a structural shift in employment. Many repetitive, lower-skilled occupations, such as sorting and assembly, are likely to experience a decline, while demand for higher-skilled roles involving human-robot collaboration is expected to grow rapidly. These roles include robot operation and maintenance, AI model training, and related technical services. However, for lower-skilled workers, the pace of job displacement is likely to outstrip the creation of new employment opportunities in the near term. This will place greater demands on workforce reskilling, income distribution, and social protection systems.

05

China intelligent robot industry outlook

I. Breakthrough priorities

China's intelligent robot industry has advanced from the initial phase of technology pilot and scenario validation into a critical phase characterized by large-scale deployment, commercialization, and broader industry penetration. Intelligent robots are becoming a foundational intelligent-equipment platform for manufacturing transformation and service-sector modernization. Supported by continued advances in artificial intelligence, embodied intelligence, and precision control, intelligent robots are reshaping cost structures, optimizing production and operating models, and creating new sources of industrial value. Concurrently, these advancements are introducing novel governance challenges, including workforce transition, the displacement of low-skilled labor, and the need for ethical frameworks governing intelligent systems.

Moving forward, the sustainable development of our industry will depend on continued progress in technology and product innovation, as well as stronger demand activation through large-scale scenario deployment. Expanding real-world applications is essential to overcoming data constraints, accelerating model iteration, reducing hardware costs, and refining industry standards. To ensure sustained industry growth, it is essential to prioritize coordinated progress across three key areas: application scenarios, policy and standards, and data.

01

Accelerate deployment through lighthouse applications

Prioritize high-value, high-volume application scenarios that offer significant commercial opportunities. By integrating robots into actual operational settings, companies can gather substantial volumes of high-quality operational data at a reduced cost. This approach reduces reliance on costly teleoperation and simulation data, while establishing a continuous data-model iteration loop.

02

Strengthen the supporting institutional framework

Additionally, it is crucial to further align policy support across both supply and demand. In order to accelerate commercialization, it is essential that industry R&D incentives be complemented by incentives for application-side deployment. Concurrently, the development of industry standards, safety certification, insurance mechanisms, compensation systems, and liability frameworks should be accelerated to quantify market risks and raise willingness to pay.

03

Establish a more flexible data compliance framework

While maintaining robust data security and privacy protection, appropriately optimize the regulatory framework governing the collection and use of human-robot interaction data. This will reduce compliance costs and support responsible data accumulation. For international markets, companies should further strengthen localized deployment capabilities, privacy protection, and cross-border data governance. They should also promote the modular integration of domestic open-source large language models with robot operating systems to meet regulatory requirements across different jurisdictions.

II. Future outlook

The long-term, high-quality development of the intelligent robot industry will depend on balancing technological innovation with effective management of its broader social impacts. This requires moving beyond single-stakeholder governance toward a collaborative ecosystem involving government, companies, universities and research institutions, and individuals. By working together, these stakeholders can promote an industry that is both innovative and well-regulated, while also being socially inclusive.

Government. As the architect of policy, regulatory frameworks, and public services, government plays a central role in ensuring the healthy and sustainable development of the industry. Continued policy and financial support should focus on strengthening the innovation ecosystem, prioritizing foundational technologies and critical supply chain gaps. Dedicated funding mechanisms should support breakthroughs in core components, advanced control systems, and embodied intelligence technologies, while encouraging long-term investment and avoiding excessive short-term speculation. Concurrently, the government should expedite the development of a tiered standards system encompassing data interfaces, safety requirements, and application guidelines. This system should be supported by regulatory sandboxes, enhanced data governance, privacy protection, and ethical frameworks for intelligent systems.

Companies. As the primary drivers of technological innovation and commercialization, companies should strike a balance between commercial value creation and broader social responsibility. It is essential that they prioritize scenario deployment as the foundation for continuous technology iteration. This will accelerate the integration of perception, models, control, and hardware. This will establish robust scenario-based data feedback loops. These loops will continuously improve environmental adaptability, operational precision, and cross-scenario generalization. From a business perspective, companies should continue exploring flexible business models such as Robot-as-a-Service, Skill-as-a-Service, and other subscription-based models to lower adoption barriers. At the same time, companies should invest in workforce reskilling to transition employees into emerging roles such as robot operation and maintenance, system commissioning, and intelligent operations management.

Universities and research institutions. As the primary source of talent development, fundamental research, and technological innovation, universities and research institutions should strengthen alignment with industry needs while advancing frontier research. This includes expanding interdisciplinary education across mechanical engineering, electronic information, artificial intelligence, and automation; deepening industry-academia collaboration through joint laboratories, training programs, and curriculum development; and increasing research investment in embodied intelligence, human-robot interaction, and AI ethics. These efforts will help accelerate technology commercialization while strengthening the industry's long-term talent pipeline.

Individuals. Individuals will play an essential role in adapting to the intelligent era, as both the ultimate beneficiaries of technological progress and active participants in the industry's transformation. Lifelong learning will become increasingly important as human-robot collaboration becomes more widespread. It is essential for professionals to cultivate abilities that complement, rather than compete with, intelligent systems. This includes but is not limited to creativity, emotional intelligence, and complex decision-making skills. Concurrent with this strategic initiative, the company will prioritize continuous learning in AI applications and intelligent equipment operation. This initiative, in conjunction with heightened awareness of technology governance and responsible adoption, will equip individuals with the skills necessary to successfully adapt to future changes in the labor market.

The long-term development of China's intelligent robot industry will require coordinated progress across technological innovation, commercial deployment, and social governance. Moving forward, sustainable growth will depend on a collaborative governance framework that clearly defines the respective roles of government, companies, universities, research institutions, and individuals. By enhancing coordination across policy guidance, industrial innovation, talent development, and workforce adaptation, China will be well positioned to maximize the economic and societal value of intelligent robot while effectively managing the risks associated with technological transformation. This collaborative approach will provide the foundation for the industry's large-scale, well-regulated, and high-quality development.

Acknowledgments

The authors would like to express our sincere appreciation to the following experts and industry practitioners for generously sharing their insights and expertise during the preparation of this report:

- **Mr. Yuanjia Li,** Director, Research and Consulting Department, Shanghai Artificial Intelligence Industry Association
- **Dr. Jianzheng Zhang,** Founder & CEO, iSAGEBOT
- **Prof. Gangtie Zheng,** Professor, School of Aerospace Engineering, Tsinghua University
- **Dr. Xiaodong Hu,** CTO, Sevnce Robotics
- **Mr. Yirong Qian,** Chief Capital Officer, ZINOVATE
- **Mr. Lei Wang,** Founder, Shanghai Qingbao Robot
- The Pudu Robotics team

Contact us

Horatio Wong
Head of Consulting
PwC China
horatio.kk.wong@cn.pwc.com

James Lee
China AI Consulting Leader
PwC Hong Kong
james.tl.lee@hk.pwc.com

Dr. Yaxiao Liu
Head of AI Institute
PwC China
yaxiao.y.liu@cn.pwc.com

Qi Chen
Partner
PwC China
qi.c.chen@cn.pwc.com

Junda Lin
Partner
Strategy& China
junda.lin@strategyand.cn.pwc.com

Clark Wang
Principal
Strategy& China
clark.wang@strategyand.cn.pwc.com