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## INDUSTRY OVERVIEW

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*The information presented in this section, unless otherwise indicated, is derived from various government publications and other publications, and from the Frost & Sullivan Report prepared by Frost & Sullivan commissioned by us. The information derived from official government sources has not been independently verified by us, the Sole Sponsor, the [REDACTED], [REDACTED], [REDACTED], any of the [REDACTED], any of our and their respective directors, supervisors, officers, representatives, employees or advisers, or any other persons or parties involved in the [REDACTED], and no representation is given as to its accuracy.*

### SOURCES OF INFORMATION

In connection with the [REDACTED], we have engaged Frost & Sullivan, an independent market research consulting firm, to conduct a detailed analysis and prepare an industry report on the markets in which we operate. Frost & Sullivan is an independent global consulting firm founded in the United States in 1961. It is principally engaged in the provision of market research consultancy services, conducting industry research, and providing market and enterprise strategies and consultancy services across various industries. We incurred a total of RMB1.16 million in fees and expenses in connection with the preparation and use of the Frost & Sullivan Report. The payment of this amount is not contingent on the success of the [REDACTED] or on the conclusions of the Frost & Sullivan Report. Except for the Frost & Sullivan Report, we did not commission any other industry report in connection with the [REDACTED].

In connection with the preparation of the Frost & Sullivan Report, Frost & Sullivan performed both primary and secondary research, and obtained knowledge, statistics, information and industry insights on the industry trends of the target research markets. Primary research involved interviewing industry insiders such as leading market players, suppliers, customers, and recognized third-party industry associations. Secondary research involved reviewing company reports, independent research reports, and data based on Frost & Sullivan’s own research database.

Our Directors confirm that, after taking reasonable care, there is no material adverse change in the overall market information since the date of the Frost & Sullivan Report that would materially qualify, contradict or have an adverse impact on such information.

### OVERVIEW OF GLOBAL AND CHINA’S SMART SERVICE ROBOTIC PRODUCTS AND SERVICES INDUSTRY

As one of the most iconic tool(s) in the era of digital economy, robots are profoundly changing the way of production and human life. Various robots are contributing to human-machine interaction and collaboration, and bring the digital economy to a new level. Robots play an increasingly important role in expediting technology innovation, promoting industrial upgrading, forging national competitive edges, and help human beings live better. The development of robot industry has become an important metric to measure a country’s abilities in technology innovation competitiveness.

#### Definition and Classification of Robot

A robot (and a robotic product) is an actuated mechanism programmable in two or more axes with a degree of autonomy, moving within its environment, to perform intended tasks. Autonomy in this context means the ability to perform intended tasks based on the information it has perceived without human intervention.

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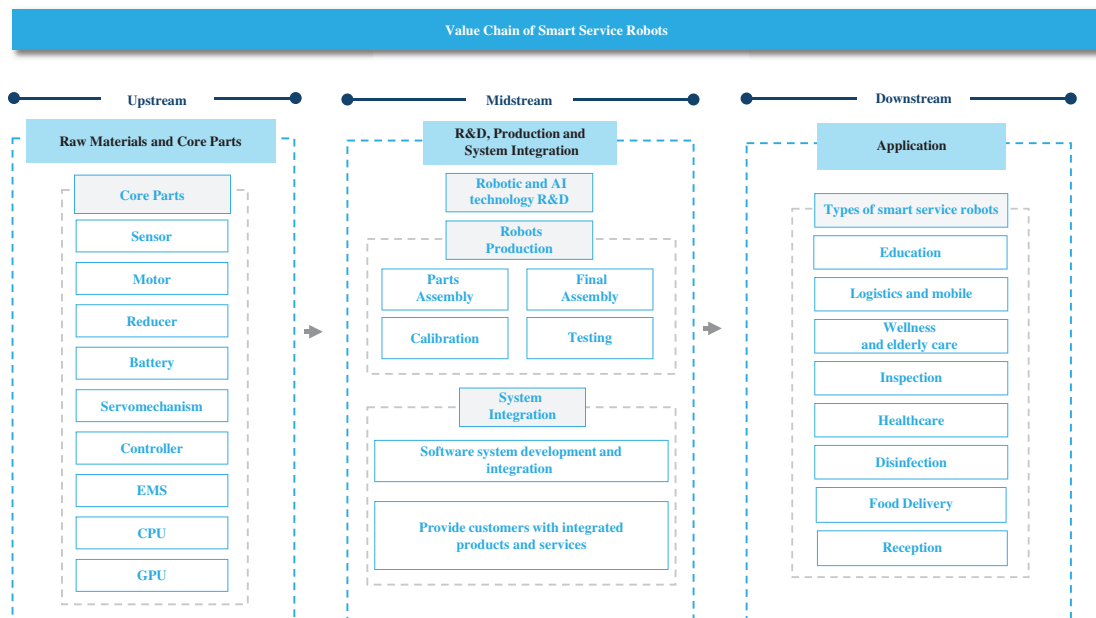
Robots can be classified by application and smart level. Under the application route, robot can be further classified into industrial robot and service robot. Service robot is a robot that performs useful tasks for humans or equipment excluding industrial robots. The highlight of service robots is their ability to have active interactions with people, which is a step up from the conventional passive interactions people have with machines. Industrial robot refers to an automatically controlled, reprogrammable multipurpose manipulator programmable in three or more axes, which can be either fixed in place or mobile for use in industrial use scenarios, such as articulated robot, cartesian robot and Selective Compliance Articulated Robot Arm (“SCARA”) robot. By smart level, robot can be classified into smart robot and non-smart robot. Smart robot is a robot with high-level autonomy that is empowered by a series of AI technologies and advanced robotic technologies, such as computer vision, voice interaction, and motion control technology, to perform advanced tasks in complicated environments.

### Definition of Smart Service Robot

Smart service robot refers to a service robot with intelligent abilities such as sensing, analyzing, and processing the information from external environment. Smart service robot can be classified into personal/domestic smart service robot and professional smart service robot. Personal/domestic smart service robot is a smart service robot used for non-commercial tasks, usually by lay persons, such as consumer-level education robot, entertainment smart robot, and personal mobility assist smart robot. Professional smart service robot is a smart service robot used for a commercial task, sometimes operated by a properly trained operator, such as enterprise-level education smart robot, logistics smart robot, food delivery smart robots, reception smart robots, inspection smart robots, and wellness and elderly care smart robot. The humanoid robots can be either professional smart service robots or personal/domestic smart service robots depending on the scenarios and objects they serve.

### Value Chain of Smart Service Robots

The upstream of smart service robot value chain includes raw materials and core parts of the smart service robot. The midstream is the R&D, which mainly consists of robotic and AI technology R&D, robot production, and system integration. The downstream is the applications of smart service robots, such as education, logistics and mobile, wellness and elderly care and inspection, to different use scenarios, etc..



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### Core Technologies of Smart Service Robots

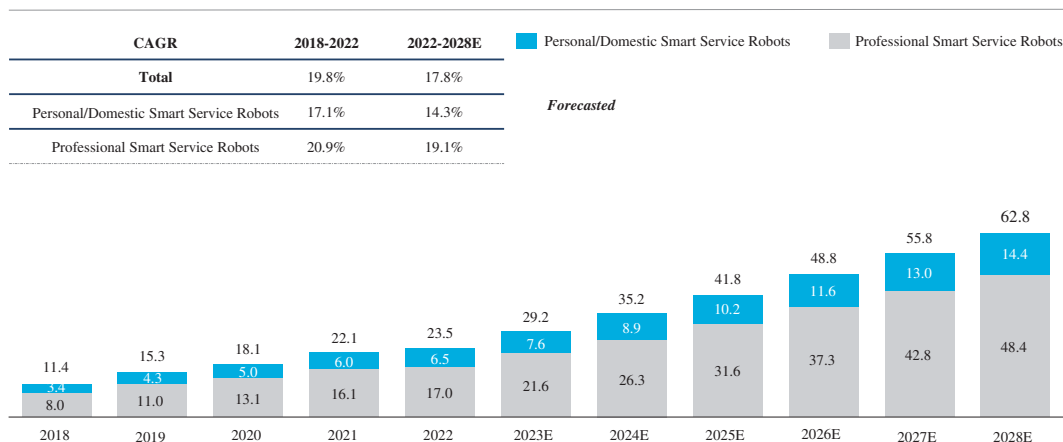
Computer vision and voice interaction enable smart service robots to realize interaction with surrounding environment, human, and other robots; movement planning and control, as well as positioning navigation enable smart service robots to move in a far more complex environment, and servo actuators further enhance the flexible and precise movements of smart service robots. Therefore, a robot company which owns full-stack core technologies have more opportunities in the future competition in the smart service robotic products and services industry.

<b>Computer Vision</b>	<ul style="list-style-type: none"> <li>Computer vision technologies enable smart service robot to identify and recognize faces, objects, and environments they encounter in a human-like vision, helping pick out details in objects for decision-making on its next actions, motion, or interaction with human.</li> </ul>
<b>Voice Interaction</b>	<ul style="list-style-type: none"> <li>Voice interaction technology is a comprehensive technology that uses voice as the basic information carrier to enable smart service robot to interact with human in a human-like manner. It integrates technologies such as Automatic Speech Recognition (ASR), Natural Language Processing (NLP), and Text-to-speech (TTS).</li> </ul>
<b>Servo Actuators</b>	<ul style="list-style-type: none"> <li>Servo actuators are joints of smart service robot that enable the performance of diverse, flexible and precise movements and perform safe, smooth, accurate and agile joint movements and carry out complex tasks, servo actuators can support rotational movement, to realize human-like movement and other application scenes.</li> </ul>
<b>Positioning Navigation</b>	<ul style="list-style-type: none"> <li>Positioning Navigation technology is a complex system that integrates multiple technologies such as sensors, perception, planning, control, and decision-making, enabling smart service robot to move from point A to point B in unfamiliar or known environments. It comprises key technologies such as positioning, mapping, navigation and obstacle avoidance.</li> </ul>
<b>Motion Planning and Control</b>	<ul style="list-style-type: none"> <li>Motion planning refers to the method of motion tasks, and control is the process of execution. Motion planning and control ensure smart service robot to accurately execute the given motion instructions, and realize functions such as operation, movement, and motion.</li> </ul>

The Group’s AI technologies can be classified as artificial narrow intelligence (ANI) as opposed to artificial general intelligence and artificial super intelligence, since they are generally developed or used only for specific and narrow tasks and/or application scenarios and cannot fully perform intellectual capabilities of human-beings at its current stage. Currently, ANI is the only form of AI used in smart service robotic products and services in the market because artificial general intelligence and artificial super intelligence are the future development form of AI and have not been fully commercialised in the market.

### Market Size of Global Smart Service Robotic Products and Services Industry

USD Billion, 2018-2028E



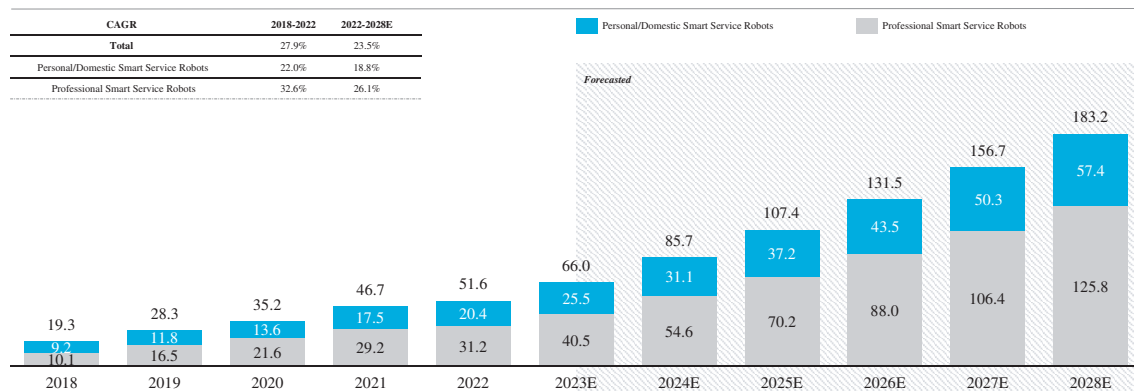
Source: International Federation of Robotics; Frost & Sullivan

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To proactively develop the robot industry has become a national strategy for many advanced economies as well as emerging economies. In particular, the continuous upgrade of robotic technologies, decrease of smart service robot price, and the gradually increasing willingness of downstream customers to accept paying for smart service robotic products and services become more widely adopted in more use scenarios accelerate the fast growth of global smart service robotic products and services market. Moreover, labor shortage and increasing labor costs further accelerated the fast penetration of smart service robotic products and services. According to Frost & Sullivan, the global smart service robotic products and services market, measured by sales revenue, has increased from USD11.4 billion in 2018 to USD23.5 billion in 2022, representing a CAGR of 19.8% during this period.

Going forward, as the types and functionalities of smart service robotic products and services expand and become more mature and flexible, it is expected that the market size of global smart service robotic products and services market will reach USD62.8 billion with a CAGR of 17.8% from 2022 to 2028, according to Frost & Sullivan.

### Market Size of China’s Smart Service Robotic Products and Services Industry



Source: International Federation of Robotics; Frost & Sullivan

China’s government has launched a series of favorable policies, such as Implementation Plan for “Robotics+” Application Action 《“机器人+”应用行动方案》 issued by the MIIT and various other PRC governmental departments in January, 2023, to promote the development of robot industry. As a consequence, the market players of China’s smart service robotic products and services industry have experienced an aggregation and synergistic effect. Moreover, the strong market demand in China provides more opportunities and confidence for smart service robotic products and services companies to launch innovative products and services. According to Frost & Sullivan, China’s smart service robotic products and services market, measured by sales revenue, has increased from RMB19.3 billion in 2018 to RMB51.6 billion in 2022, representing a CAGR of 27.9% during this period.

The penetration rate of smart service robotic products and services in the PRC is remained low in recent years. The low penetration rate of smart service robotic products and services industry can be attributed to several factors, including: (i) High cost: Smart service robotic products and services can be expensive to develop and deploy, making them unaffordable for many businesses and consumers; (ii) Limited functionality: Many smart service robotic products and services have limited functionality and are not yet capable of performing complex tasks that humans can do, making them less attractive to potential users; (iii) Lack of awareness: Many businesses and consumers are not aware of the potential benefits of using smart service robotic products and services, or they may not understand how to use them effectively; and (iv) Technical challenges: Developing and deploying smart service robotic products and services can be challenging, requiring specialized skills and expertise that are not widely available.

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Going forward, it is expected that the cutting-edge AI technologies will shape the development of China’s smart service robotic products and services market significantly in the next few years, and the use scenarios of smart service robotic products and services in China will be further explored. Moreover, the continuous upgrades of appearance and functionality of personal/domestic use smart service robotic products for non-commercial tasks as well as the compelling application at a competitive price will further stimulate the growth of personal/domestic smart service robotic products and services market. According to Frost & Sullivan, China’s smart service robotic products and services market will reach RMB183.2 billion with a CAGR of 23.5% from 2022 to 2028.

### **Market Drivers of China’s Smart Service Robotic Products and Services Industry**

#### ***Favorable Policies to Propel the Development of China’s Smart Service Robotic Products and Services Industry***

The smart service robotic products and services industry is considered as an important industry by the Chinese government, and the Chinese government has promulgated a series of favorable policies to propel the development of the smart service robotic products and services industry. For example, in 2021, the “14th Five-Year Plan for Development of Chinese Robotics Industry” was promulgated to claim “breakthroughs will be made during the period in a number of core technologies and high-end products of robots”. In the national plan “Made in China 2025”, the robot industry was listed along with artificial intelligence and automation, as one of the priority sectors for high-level development that promote the transformation and upgrading of the manufacturing industry. In 2023, the MIIT and various other PRC governmental departments jointly issued Implementation Plan for “Robotics+” Application Action 《“機器人+”應用行動實施方案》, which proposes (i) the depth and breadth of application of service robots and special robots in various industries including, among others, manufacturing, agricultural, construction, energy and logistics; and (ii) the ability of robots to promote high-quality economic and social development would be significantly enhanced.

#### ***Increasing Demands Due to Labor Shortage and Increasing Labor Costs***

From 2020 to 2030, China’s working-age population is estimated to drop from 989 million to 963 million, and the labor participation rate is estimated to decline from 68.4% to 65.2%. Besides, the average labor costs in China have increased significantly. From 2018 to 2022, the average annual wage of urban employees increased from RMB82.4 thousand to RMB114.0 thousand, representing a CAGR of 8.5% during the same period. As a result, there are huge demands from many industries for utilizing smart service robotic products and services to address the challenges associated with labor shortage and increasing labor costs.

### **Advancement of Core Technologies in Smart Service Robotic Products and Services Industry**

Previous robotic products and services, which have no or limited AI capabilities, or limited robot device technologies, such as joint movement, face significant challenges in production costs, as well as the efficiently and effectively of perceiving and analyzing the information from the real world, planning and making decision based on the results of its analysis, or interacting with people, then hinder the wide adoption of robotic products and services. Thanks to the advancements of AI technologies, these challenges are well addressed, and the application of stronger AI technologies propels the rapid growth of the smart service robotic products and services market. The opportunities for AI-empowered robots in the world and China are driven not only by the sheer size of the market, but also by the need to enhance and enrich our daily lives through robotic technology and innovations. For instance, the voice interaction and computer vision technologies enable reception robots to identify and recognize human and surrounding objects and have conversations with human; positioning navigation, motion planning and control enable food delivery robots and logistics robots to deliver food and goods to designated places autonomously in a complex environment; and servo actuators further enhance the flexible and precise movements of smart service robots. The advancement of AI technologies transformed robots from passive interaction to active interaction with human, addresses limitations of traditional robotic products and services.

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### ***Increasing Consumer Acceptance of Smart Service Robotic Products and Services***

With the advancement of AI and robotic technologies, as well as the encouragement of digitalization across industries in China, more enterprises started to adopt smart service robotic products and services to increase work efficiency and safety. Hence, for the past several years, the smart service robotic products and services industry has gradually matured, costumers are willing to pay for it for the cost effectiveness and satisfied user experience.

### **Market Trends of China’s Smart Service Robotic Products and Services Industry**

#### ***Robots Will Become Smarter with the Further Advancement of AI Technologies***

The further upgrades of AI technologies will propel the deeper applications of smart service robots across industries. The emerging technologies such as ChatGPT, have been rapidly extended to many applications including humanoid robot intuitive operation. Current robotics pipelines begin with an engineer or technical staff who needs to translate the tasks’ requirements into code to implement applications. In contrast, when ChatGPT evolves to provide multi-modal AI capabilities (instead of conversation only), it will enable people to develop various robotic applications (such as making coffee, bringing a chair, fetching medicine) much more easily, without the need to learn complex programming skills or robotic AI algorithms. With the further development of GPT based multi-modal AI, (such as integration of computer vision, NLP, and motion control), robot empowered by multi-modal AI will be able to conduct complex tasks automatically, such as walking and grasping, using screwdriver, and assemble a chair, without complicated programming.

#### ***Smart Service Robotic Products and Services Will be Introduced Into More Industries and Use Scenarios***

From providing indoor delivery to offering services in wellness and elderly care scenarios, smart service robots are making humans’ lives easier and helping businesses across industries improve productivity and enhance the customer experience. Across industries, robotic and AI technologies have enabled innovative products and services to the challenges faced by businesses of all sizes. Companies are utilizing smart service robots to bring humans and technology closer together, solving problems, and transforming their business models to meet evolving demands.

#### ***Trend of Humanoid Robots***

Humanoid robot is a major carrier of AI technologies and allows human to experience the advanced AI technologies more intuitively. Compared to other types of robot, humanoid robot is more ergonomic, and can adapt more quickly to human’s living and working environments, and their human-like appearance can make them more approachable in daily life, and working environments.

#### ***Shifting of Business Models from Provision of “Products” to Provision of “Products + Services”***

With the deeper understanding of industry pinpoint and the further development of robotic technologies, smart service robotic products and services companies nowadays are able to provide both smart service robotic products and services instead of just smart service robotic products. For instance, professional smart service robots can collect analytical data for decision making, and elderly care robots are able to achieve real-time connection between the elder people with hospitals to avoid emergency situations. For smart service robotic products and services companies, the proliferation of integrated products and services offerings which contains both products and services can maximize the instinct value of smart service robots, and also explore their business models.

#### ***Prevalence of Modular for R&D of Smart Service Robots***

Modular technology can significantly increase the speed of developing new products and reduce manufacturing costs, which provide the overall system of smart service robots with versatility scalability, and configurability, as well as increase fault tolerance. The high efficiency, accuracy and cost advantages of modular technology design have been fully reflected in R&D and production of smart service robots.

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### Entry Barriers of China’s Smart Service Robotic Products and Services Industry

#### *Intensive and Continuous R&D Investment on Robotics Technologies*

Through diversification and the establishment of robotic technologies, investments in new robotic technologies have increased significantly, meanwhile, the application spectrum of R&D on robotics has expanded. The continuous updates of technologies, such as artificial intelligence, Big Data and 5G will drive smart service robotic products and services companies to further invest in robotic technologies, in order to catch up the possibilities that could make smart service robots more intelligent.

#### *Sufficient Industry Know-how*

Industry leaders have accumulated enough industry know-how to develop their product line and market strategy. New entrants may lack this industry knowledge, which can result in a misunderstanding of customer preferences and make it difficult for them to invent competitive products that can gain market share in the long run.

#### *Barriers for New Entrants to Establish Brand Recognition*

The products and services of market pioneers have gained high brand recognition and wide customer recognition in the industry, placing them in a leading position for market expansion. It is difficult for new entrants to establish brand recognition, or establish a strong connection in the industry supply chain within a short period of time.

### COMPETITIVE LANDSCAPE OF CHINA’S SMART SERVICE ROBOTIC PRODUCTS AND SERVICES INDUSTRY

#### Overview of Major Players

The competition of China’s smart service robotic products and services industry is keen and fragmented since the industry is still at an early stage and there are only a few players in this industry who are able to provide full-stack core technologies, which include computer vision, voice interaction, servo actuators, motion planning and control, and positioning navigation, with many industry players seeking to enter into the market by developing the same or similar technologies. According to Frost & Sullivan, we ranked 3rd in China’s smart service robotic products and services industry in terms of revenue in 2022 and we are one of the two companies among top five that have full-stack core technologies capabilities. The following table illustrates the information of top five players:

Ranking	Company	Overview	Registered Capital (RMB Million)	Listing Status	Geographical Coverage of Products	Type of smart service robot	Fullstack core technologies	Revenue of smart service robotic products and services in China 2022 (RMB, Billion)	Market share in 2022
1	CloudMinds	<ul style="list-style-type: none"> <li>Founded in 2015, headquartered in Shanghai, China. The company specialized in cloud-based robot and operation platform</li> </ul>	• 1,366	• Not listed	• China	• Public smart service robot	✓	• 2.0	• 6.4%
2	HIKROBOT	<ul style="list-style-type: none"> <li>Founded in 2016, headquartered in Hangzhou, China. The company provides customers with machine vision products and mobile robots</li> </ul>	• 720	• In Progress of Shenzhen Stock Exchange	• China and over 50 overseas countries and regions	• Logistics smart robot	/	• 1.5	• 4.6%
3	UBTECH	<ul style="list-style-type: none"> <li>Founded in 2012, headquartered in Shenzhen, China. The company is an established smart service robotic products and services provider in China</li> </ul>	• 407	• [REDACTED]	• China and over 50 overseas countries and regions	<ul style="list-style-type: none"> <li>• Education smart robot</li> <li>• Logistics smart robot</li> <li>• General service robot</li> </ul>	✓	• 0.9	• 2.8%
4	SGAI	<ul style="list-style-type: none"> <li>Founded in 2000, headquartered in Jinan, China. The company is specialized in inspection robot in electronic industry</li> </ul>	• 150	• Not listed	• China	• Inspection smart robot	/	• 0.9	• 2.7%
5	Geek+	<ul style="list-style-type: none"> <li>Founded in 2015, headquartered in Beijing, China. It is a products and services provider in the logistics and mobile smart robotic product and services industry</li> </ul>	• 1,159	• Not listed	• China, and over 40 overseas countries and regions	• Logistics smart robot	/	• 0.7	• 2.2%

Source: Interviews with industry players; Frost & Sullivan

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### Price Range of Major Raw Materials for the Production of Smart Service Robots

- A smart service robot comprises of hundreds of raw materials whose attributes, functions, and prices significantly vary between each other. The major raw materials for the production of smart service robots are mainly include sensors, integrated circuits, soldering tin stick, capacitors, PCB boards, potentiometers, and compliers (composed of software and hardware), the cost of these raw materials accounts for approximately 45% of total raw materials of a smart service robot. Many raw materials, such as frame parts or cables, are common goods in smart devices market, and have sufficient supply and relatively limited price fluctuations. Therefore, there is no specific price trend for the raw materials used in the products of the Group. Given the variety of raw materials of a smart service robot, the correlation of smart service robotic products price and different raw materials is relatively low. The price changes of one or several raw materials may not have material impacts on the final price of a smart service robot.

Major raw materials	Price Range Per Unit from 2020 to 2022(RMB)			Key factors affecting the prices
Sensors	0.4 – 20,000			<ul style="list-style-type: none"> <li>• Types of sensors and their functionalities; for example, the average price of some simple ambient light sensors is only around RMB0.4, while the price of high-end sensors with more advanced functionalities, such as six-axis force sensors, can exceed RMB15,000</li> <li>• Production capacity of manufacturers</li> </ul>
Integrated circuits (ICs)	0.1 - 100			<ul style="list-style-type: none"> <li>• Types of ICs and their functionalities; for example, the average price of some power management IC such as LDO, DC-DC converters, or interface ICs, is usually less than RMB5, while the average price of some application processors, such as CPU, can exceed RMB50</li> <li>• Production capacity of manufacturers</li> </ul>
Soldering Tin Stick	150 - 300/kg (2020)	160 - 340/kg (2021)	170 - 380/kg (2022)	<ul style="list-style-type: none"> <li>• Types of Soldering Tin Stick (with lead or lead-free)</li> <li>• Price changes of upstream raw materials</li> </ul>
Capacitors	0.002 - 3			<ul style="list-style-type: none"> <li>• Types of raw materials and specifications of capacitors</li> </ul>
PCB boards	0.5 - 350			<ul style="list-style-type: none"> <li>• Raw materials, size of board, number of layers, size of hole, minimum trace and space, thickness and aspect ratio, quantity of order, and custom specifications</li> </ul>
Potentiometers	1.3 - 2.5			<ul style="list-style-type: none"> <li>• Specifications of potentiometers</li> </ul>
Compliers (composed of software and hardware)	1,100 – 1,700			<ul style="list-style-type: none"> <li>• Quantity of order, custom specifications</li> </ul>

Source: Frost & Sullivan



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### OVERVIEW OF KEY SEGMENTS OF SMART SERVICE ROBOTIC PRODUCTS AND SERVICES INDUSTRY IN CHINA BY USE SCENARIOS

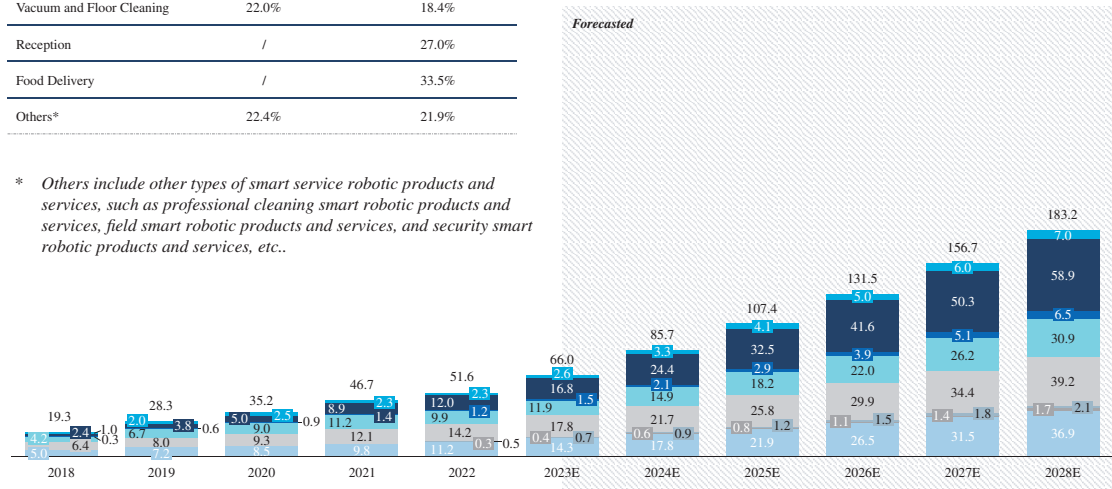
#### The Breakdown of Market Revenue of Smart Service Robotic Products and Services in China by Key Segments

RMB Billion, 2018-2028E

CAGR	2018-2022	2022-2028E
<b>Total</b>	<b>27.9%</b>	<b>23.5%</b>
Education	23.1%	20.4%
Logistics and Mobile	49.5%	30.4%
Wellness and Elderly Care	41.4%	32.5%
Inspection	23.9%	20.9%
Vacuum and Floor Cleaning	22.0%	18.4%
Reception	/	27.0%
Food Delivery	/	33.5%
Others*	22.4%	21.9%

- Education Smart Robotic Products and Services
- Logistics and Mobile Smart Robotic Products and Services
- Wellness and Elderly Care Smart Robotic Products and Services
- Inspection Smart Robotic Products and Services
- Vacuum and Floor Cleaning Robotic Product
- Reception Smart Robotic Products and Services
- Food Delivery Smart Robotic Products and Services
- Others

\* Others include other types of smart service robotic products and services, such as professional cleaning smart robotic products and services, field smart robotic products and services, and security smart robotic products and services, etc..



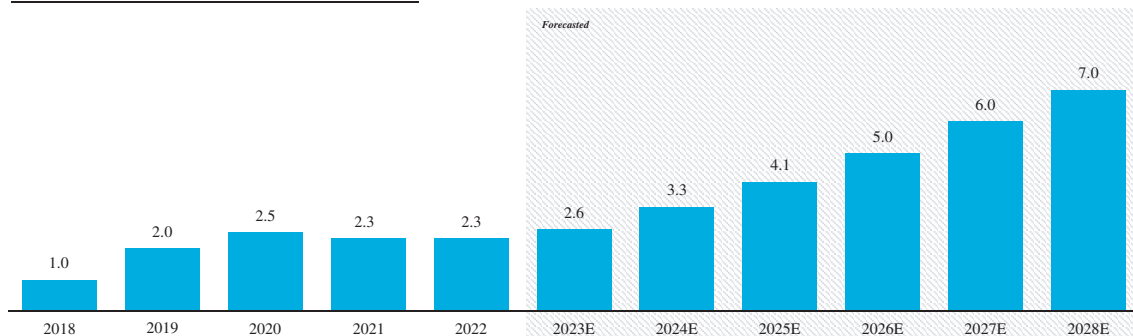
Source: International Federation of Robotics; Frost & Sullivan

### Education Smart Robotic Products and Services Industry

#### Market Size of China's Education Smart Robotic Products and Services Industry

RMB Billion, 2018-2028E

CAGR	2018-2022	2022-2028E
Education Smart Robots	23.1%	20.4%



Source: Interviews with industry players; Frost & Sullivan

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Education smart robotic products and services (i) mean education robotic products and services that utilize any AI technologies, rather than the common hardware including computers and projectors, used in the teaching process; (ii) consist of education smart robotic products and supplementary software and services (e.g. AI smart education platform and AI education curriculum); (iii) are used as teaching tools to assist students in STEAM curricula learning, such as AI and programming learning; and (iv) are aimed at enterprise-level customers, including schools and educational institutions, as their downstream customers, rather than individual consumers. The market size of China’s education smart robotic products and services industry, measured by sales revenue, has reached RMB2.3 billion in 2022 from RMB1.0 billion in 2018, with a CAGR of 23.1% from 2018 to 2022. The market sentiment towards China’s education smart robotic products and services industry was not good in 2021 and decreased as compared to the market size in 2020, according to Frost & Sullivan. Moreover, the PRC government issued the “Opinions on Further Reducing the Burden of Students’ Homework and Off-campus Training in Compulsory Education” in mid-2021, but since the application of education smart robots are related to AI subjects instead of compulsory subjects and are not subject to relevant restrictive policies, the sales revenue has not been affected in 2022.

As the number of local governments which have announced favorable policies to promote AI-related courses remains relatively low, the penetration rate of the education smart robotic products and services industry in the PRC was approximately 8% in the years ended December 31, 2022. Such penetration rates remained low primarily because (i) while the State Council released the first AI education related policy, namely the New Generation of Artificial Intelligence Development Plan in 2017, local governments of provinces and cities such as Zhejiang Province and Shenzhen City only gradually announced its policies to promote or include AI education as a compulsory part of school curriculum in the recent two to three years, which resulted in low penetration rate of smart service robotic products and services in education smart robotic products and services industry in the PRC; and (ii) the adoption of education smart robotic products and services requires relatively high investment from local governments and schools which resulted in the overall slow application in educational scenario.

Looking forward, with the promotion of artificial intelligence education by the government and the expansion of the AI laboratories and programming laboratories in schools, the market base for education smart robotic products and services will continue to expand, and it is expected the market size will reach RMB7.0 billion by 2028, representing a CAGR of 20.4% from 2022 to 2028.

### ***Market Drivers of China’s Education Smart Robotic Products and Services Industry***

#### ***Policy Support***

Policy support is a major factor of the rapid development of China’s education smart robotic products and services industry. For example, the 14th Five Year Plan for National Informatization proposed that in order to improve the level of the infrastructure of the campus, it is necessary to further implement the construction of digital campuses and accelerate the upgrade of digital and intelligent facilities for teaching, experiments, research, management and services at all kinds of schools.

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The PRC government pays more attention to programming and robotics education in recent years. To promote development and application of education robots, a series of policies have been issued. In 2018, Educational Informatization 2.0 Action Plan emphasized the need to strengthen the research and application of intelligent teaching assistants and education smart robots. Moreover, the “double reduction” policy issued by the PRC government in mid 2021 has facilitated the development of enrichment learning. Opinions on Strengthening Scientific Education in Primary and Secondary Schools in the New Era issued in 2023 proposed to promote science education in primary and secondary schools based on practices, stimulate students’ imagination, and cultivate students’ interest in science. Therefore, it has led to the situation that the education smart robots were not only be applied in “out of school education” and training institutions, but also be brought into schools. Students will also have more time to develop their interest after school.

### *The prevalence of innovation in the teaching process*

Compared to traditional teaching and learning scenarios, innovative teaching modes that incorporate various enrichment learning and teaching classes, including AI, have shattered the conventional restrictions. As a result, these models significantly cultivate the comprehensive literacy of Generation Z or post-00s individuals, and empower an interactive and technologically-driven teaching process. Therefore, the prevalence of such innovation in the teaching steps drives the growth of the education smart robotic products and services industry.

### ***Market Trends of China’s Education Smart Robotic Products and Services Industry***

#### *Product Innovation and Expansion of Supporting Services*

Benefiting from the continuous development of machine learning, AI, and other technologies, the education smart robotic products and services industry will continue to innovate product forms and optimize product performance. For instance, there will be an increasing demand of humanoid robots to serve as educational tools for learning purpose. Furthermore, in order to enhance the learning and using experience supported by education smart robots, more and more market players will engage in providing related services, such as robot competitions, professional curriculum content, robot culture, science and technology activities, teacher training and so on.

#### *Robotic education is increasingly being introduced into schools and educational institutions*

At the present stage, programme writing education robot in primary and secondary education mainly appears in the form of robot competition and extracurricular robot training. Looking forward, with promotion of strengthening AI education in China and the support of the government’s favorable policies, the number of programming laboratories will start to increase and AI subjects will prevail in many schools and educational institutions. Meanwhile, education smart robots will gradually be applied in an increasing number of schools and educational institutions to cultivate students’ comprehensive ability in an all-round way and improve their competitiveness.

## INDUSTRY OVERVIEW

### Competitive Landscape of China’s Education Smart Robotic Products and Services Industry

According to Frost & Sullivan, the competitive landscape of China’s education smart robotic products and services industry is fragmented with more than 50 market players and we ranked first and accounted for 22.5% market share of the industry in terms of revenue in 2022. The table set forth below illustrates the information of the top five market players in China’s education smart robotic products and services industry:

Ranking	Company	Overview	Listing Status	Geographical Coverage of Products	Number of employees (As of Dec 31, 2022)	Introduction of education smart robotic products and services	Sales revenue of education smart robotic products and services in China in 2022 (RMB, million)	Market share in 2022
1	UBTECH	<ul style="list-style-type: none"> <li>Founded in 2012, headquartered in Shenzhen, China. The company is an established smart service robotic products and services provider in China.</li> </ul>	• [REDACTED]	<ul style="list-style-type: none"> <li>China and over 50 overseas countries and regions</li> </ul>	• 1,692	<ul style="list-style-type: none"> <li>It engages in provision of education smart robotic products and services in both enterprise-level and consumer-level.</li> </ul>	• 517	• 22.5%
2	Shengtong	<ul style="list-style-type: none"> <li>A public company founded in 2000, listed on SZSE, and headquartered in Beijing, China. The company primarily engages in the printing and smart education industry.</li> </ul>	• Listed on the Shenzhen Stock Exchange	<ul style="list-style-type: none"> <li>China, Israel</li> </ul>	• Around 3,300	<ul style="list-style-type: none"> <li>It provides a wide range of tech-enabled services and products associated with programme writing education, robotic education, and education smart robots.</li> </ul>	• 92	• 4.0%
3	WhalesBot	<ul style="list-style-type: none"> <li>Founded in 2018, headquartered in Shanghai, China. The company is a robotics products and services provider for the youth education.</li> </ul>	• Not listed	<ul style="list-style-type: none"> <li>China and over 26 countries and regions</li> </ul>	• Around 100	<ul style="list-style-type: none"> <li>It provides education smart robots, programmable robotics kits, or other educational robotic services for schools and competitions.</li> </ul>	• 52	• 2.2%
4	DJI	<ul style="list-style-type: none"> <li>Founded in 2006, headquartered in Shenzhen, China. It engages in designing and manufacturing action cameras, camera stabilizers, unmanned aerial vehicles (drones) for photography and videography.</li> </ul>	• Not listed	<ul style="list-style-type: none"> <li>China, the United States, Germany, the Netherlands, Japan, South Korea</li> </ul>	• Around 14,000	<ul style="list-style-type: none"> <li>It provides a wide range of education smart robotic products and services for learners.</li> </ul>	• 50	• 2.2%
5	Makeblock	<ul style="list-style-type: none"> <li>Founded in 2013, headquartered in Shenzhen, China. It primarily provides schools with robotics hardware, software, and teaching content.</li> </ul>	• Not listed	<ul style="list-style-type: none"> <li>China and over 140 countries and regions</li> </ul>	• More than 500	<ul style="list-style-type: none"> <li>It provides educational smart robotic products and services, such as robotic kits and robotic teaching resources for schools.</li> </ul>	• 45	• 2.0%

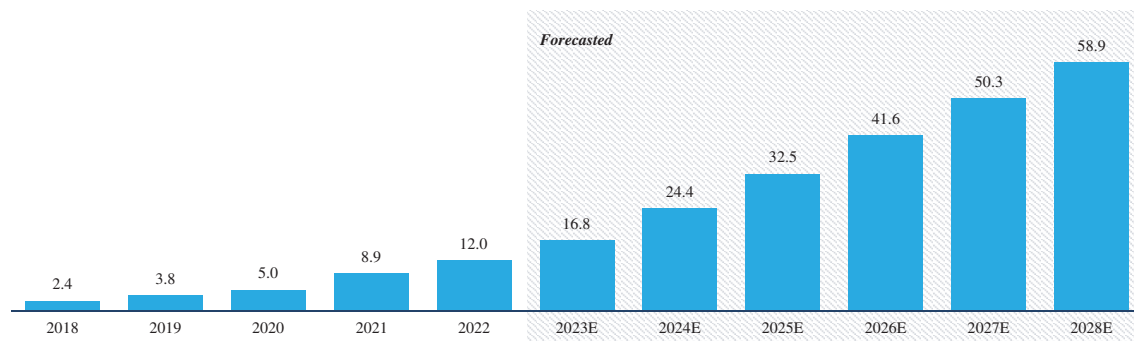
Source: Interviews with industry players; Frost & Sullivan

### Logistics and Mobile Smart Robotic Products and Services Industry

#### Market Size of China’s Logistics and Mobile Smart Robotic Products and Services Industry

RMB Billion, 2018-2028E

	CAGR	2018-2022	2022-2028E
Logistics and Mobile Smart Robots		49.5%	30.4%



Source: Mobile Robot and AGV/AMR Industry Alliance; Frost & Sullivan

Driven by a rising application scenarios of logistics and mobile smart robots such as warehouse picking and distribution, according to Frost & Sullivan, the market size of China’s logistics and mobile smart robotic products and services industry, which measured by sales revenue has increased from RMB2.4 billion in 2018 to RMB12.0 billion in 2022, with a CAGR of 49.5% during this period.

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## INDUSTRY OVERVIEW

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According to Frost & Sullivan, the penetration rate of logistics and mobile smart robotic products and services industry in the PRC is still relatively low, since: (1) it takes time for end customers with different business scales and the willingness to undergo digital transformation to adopt and pay for such products and services; (2) there is a high initial investment cost required for customers to transform traditional factories into smart factories. Moreover, as logistics and mobile smart robotic products and services can be widely used in different scenarios of various industry verticals, it is difficult to identify the number of customers in each different scenario. As a result, it is not feasible to calculate the penetration rate corresponding to the total demand for logistics and mobile smart robotic products and services.

Due to the need for manufacturers and logistics companies to automate their production and/or storage facilities to maximize their operational efficiency, as well as the shortage of manufacturing workers and the rising labor cost of China’s manufacturing industry, the demand for logistics and mobile smart robotic products and services will continue to grow at a high speed in the future. It is expected that the market size will reach RMB58.9 billion by 2028, with a CAGR of 30.4% from 2022 to 2028, according to Frost & Sullivan.

### ***Market Drivers of China’s Logistics and Mobile Smart Robotic Products and Services Industry***

#### *The transformation of manufacturing industry in China*

Thanks to the improvement of innovation capabilities, China’s manufacturing industry is gradually shifting from low-end processing to high-end value-added products. At the same time, with the promotion of new technologies such as AI, China’s manufacturing industry has begun to transform towards the orientation of intelligence, and thus driven the market demand for logistics and mobile smart robotic products and services.

#### *Rise of new retail and e-commerce industry*

In recent years, logistics and warehousing systems have been increasingly automated to improve efficiency and cost control. At the same time, the new retail and e-commerce industries, which are highly relying on logistics and warehousing systems, are experiencing a rapid expansion. As a result, logistics and mobile smart robots are considered a major automation investment for further optimization of logistics systems, driven by both market demand and product iterations.

#### *Increasing Demands Due to The shortage of labor*

China’s labor force continues to decline in recent years due to decline in birth rate, which causes the rise of labor cost. The rising labor cost, coupled with the younger generation’s unwillingness to engage in manual labor, has created a serious shortage of manufacturing workers. At the same time, with the maturity of production technology, the price of robots continues to decline, creating a strong demand for logistics and mobile smart robots to replace labor.

### ***Market Trends of China’s Logistics and Mobile Smart Robotic Products and Services Industry***

#### *Further Demand of Logistics and Mobile Smart Robotic Products and Services in Warehousing and Production Process*

Market participants in manufacturing businesses which adopt logistics and mobile smart robotic products and services instead of relying on labor intensive model will benefit from most cost-efficient and effective manner due to lower production costs resulting from longer working hours and comparatively consistent quality standards in general. There is an increasing trend for automobile manufacturers to incorporate logistics and mobile smart robotic products and services into its warehousing and production processes, as traditional labor may not be able to provide consistent and safe handling of automobile components, semi-finished products and finished products due to their heavy and fragile nature.

#### *Integration of Equipment and Management System*

Technologies in warehousing and production line logistics such as AGVs, AMRs, can be applied to various usages such as handling, transportation, storage, and picking. It can greatly improve the

## INDUSTRY OVERVIEW

efficiency of warehousing and logistics. Intelligent warehousing will be more closely integrated with the companies’ technological process and become an integral part of production logistics and sales logistics.

### *The change from “shelves-to-person” to “case-to-person”*

The design of logistics smart robotic products in China basically refers to the operation mode of Kiva robot. When picking a package, the Kiva robot moves the entire shelf where the package is in front of the warehouse staff, commonly known as “shelves-to-person”. However, the transportation mode of carrying the whole shelf for a single package is not only a waste of resource, but also prone to safety accidents in the warehouse. With the gradual maturity of logistics and mobile smart robot technology, since the “case-to-person” mode can provide the exact goods demanded by orders in a more precise way, it will replace the “shelves-to-person” mode and gradually become the mainstream of picking technology in the logistics industry.

### *Market Opportunities of Logistics and Mobile Smart Robotic Products and Services in Outdoor Scenarios*

With the growth in the number of outdoor scenarios such as smart industrial parks in China, and the expansion of the need to place certain production facilities and equipment outdoors due to efficiency and safety concerns in the production process there will be a huge market opportunity of logistics and mobile smart robotic products and services in outdoor scenarios with uneven terrain and exposure to extreme weather conditions to overcome the technical barriers associated with outdoor production and shipping processes.

### **Competitive Landscape of China’s Logistics and Mobile Smart Robotic Products and Services Industry**

According to Frost & Sullivan, China’s logistics and mobile smart robotic products and services industry is fragmented with more than 50 market players and the top five market players accounted for 32.5% market share of the industry in terms of revenue in 2022. According to Frost & Sullivan, we ranked seventh and accounted for 2.2% market share of China’s logistics and mobile smart robotic products and services industry in terms of revenue in 2022. The table set forth below illustrates the information of the top five market players in China’s logistics and mobile smart robotic products and services industry:

Ranking	Company	Overview	Listing Status	Geographical Coverage of Products	Number of employees (As of Dec 31, 2022)	Introduction of logistics and mobile smart robotic products and services	Sales revenue of logistics and mobile smart robotic products and services in China in 2022 (RMB, million)	Market share in 2022
1	HIKROBOT	<ul style="list-style-type: none"> <li>Founded in 2016, headquartered in Hangzhou, China. The company provides customers with machine vision products and mobile robots.</li> </ul>	<ul style="list-style-type: none"> <li>In Progress of Shenzhen Stock Exchange</li> </ul>	<ul style="list-style-type: none"> <li>China and over 50 overseas countries and regions</li> </ul>	<ul style="list-style-type: none"> <li>Around 3,410</li> </ul>	<ul style="list-style-type: none"> <li>It provides customers with mobile smart robots and systems, and build smart internal logistics products and services in industrial factories.</li> </ul>	<ul style="list-style-type: none"> <li>1,515</li> </ul>	<ul style="list-style-type: none"> <li>12.6%</li> </ul>
2	Geek+	<ul style="list-style-type: none"> <li>Founded in 2015, headquartered in Beijing, China. It is a products and services provider in the logistics and mobile smart robotic products and services industry.</li> </ul>	<ul style="list-style-type: none"> <li>Not listed</li> </ul>	<ul style="list-style-type: none"> <li>China, and over 40 overseas countries and regions</li> </ul>	<ul style="list-style-type: none"> <li>More than 1,500</li> </ul>	<ul style="list-style-type: none"> <li>It primarily provides autonomous mobile robotic (AMRS) products and services for smart warehouses or factories.</li> </ul>	<ul style="list-style-type: none"> <li>690</li> </ul>	<ul style="list-style-type: none"> <li>5.8%</li> </ul>
3	OMH	<ul style="list-style-type: none"> <li>A public company founded in 1995, headquartered in Taiyuan, China. The company is a smart manufacturing service provider.</li> </ul>	<ul style="list-style-type: none"> <li>Listed on the Shenzhen Stock Exchange</li> </ul>	<ul style="list-style-type: none"> <li>China, Thailand, Malaysia, United States, Canada, and other countries</li> </ul>	<ul style="list-style-type: none"> <li>Around 1,500</li> </ul>	<ul style="list-style-type: none"> <li>It engages in empowering logistics smart and distribution products and services by AGVs including conveyors, tuggers, and fork lifts.</li> </ul>	<ul style="list-style-type: none"> <li>656</li> </ul>	<ul style="list-style-type: none"> <li>5.5%</li> </ul>
4	Gen-song	<ul style="list-style-type: none"> <li>A public company founded in 2007, headquartered in Hefei, China. The company is a comprehensive products and services provider in the manufacturing smart and logistics smart industry.</li> </ul>	<ul style="list-style-type: none"> <li>Listed on the Shanghai Stock Exchange</li> </ul>	<ul style="list-style-type: none"> <li>China</li> </ul>	<ul style="list-style-type: none"> <li>Around 550</li> </ul>	<ul style="list-style-type: none"> <li>It is dedicated to providing customers with smart logistics and mobile products and services based on types of AGVs.</li> </ul>	<ul style="list-style-type: none"> <li>567</li> </ul>	<ul style="list-style-type: none"> <li>4.7%</li> </ul>
5	HAI ROBOTICS	<ul style="list-style-type: none"> <li>Founded in 2016, headquartered in Shenzhen, China. The company is a logistics smart robotic products and services provider to empower warehouse and factory.</li> </ul>	<ul style="list-style-type: none"> <li>Not listed</li> </ul>	<ul style="list-style-type: none"> <li>China and over 30 overseas countries and regions</li> </ul>	<ul style="list-style-type: none"> <li>More than 1,600</li> </ul>	<ul style="list-style-type: none"> <li>It is dedicated to providing robotic warehouse products and services in various industries.</li> </ul>	<ul style="list-style-type: none"> <li>470</li> </ul>	<ul style="list-style-type: none"> <li>3.9%</li> </ul>

Source: Interviews with industry players; Frost & Sullivan

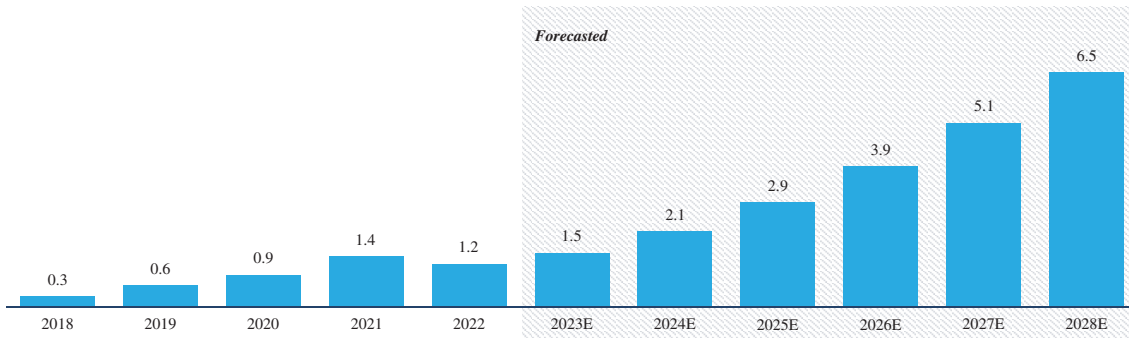
## INDUSTRY OVERVIEW

### Wellness and Elderly Care Smart Robotic Products and Services Industry

#### Market Size of China’s Wellness and Elderly Care Smart Robotic Products and Services Industry

RMB Billion, 2018-2028E

	CAGR	2018-2022	2022-2028E
Wellness and Elderly Care Smart Robots		41.4%	32.5%



Source: Interviews with industry players; Frost & Sullivan

According to Frost & Sullivan, China’s wellness and elderly care smart robotic products and services market, measured by sales revenue, has increased from RMB0.3 billion in 2018 to RMB1.2 billion in 2022, with a CAGR of 41.4% during this period. Under the influence of the shortage of long-term care workers and an upward trend in aging population in China, the demand of wellness and elderly care smart robots has increased.

According to Frost & Sullivan, the penetration rate of wellness and elderly care smart robotic products and services industry remains low as it is still at its early stage along with a limited number of technically mature market players and weak market acceptance. Moreover, the lack of technological familiarity can make it challenging for the elderly to adopt and adapt to wellness and elderly care smart robotic products and services, leading to low penetration rates. However, it is difficult to identify the total number of customers as wellness and elderly care smart robotic products and services can be applied in various scenarios such as hospitals, nursing homes. As a result, it is not feasible to calculate the penetration rate corresponding to the total demand for wellness and elderly care smart robotic products and services.

Looking forward, driven by the advancement of the technologies and the iteration of sensors, the wellness and elderly care smart robots will be commercialized, and also there is much room for growth in wellness and elderly care smart robotic products and services market, and the market size will reach RMB6.5 billion by 2028, representing a CAGR of 32.5%, according to Frost & Sullivan.

#### Market Drivers of China’s Wellness and Elderly Care Smart Robotic Products and Services Industry

##### Increasing Aging Population

According to the National Bureau of Statistics of China, the number of people aged 60 and above in China was 280.0 million as of 2022, accounting for 19.8% of the country’s total population; among them, 209.8 million were aged 65 and above, accounting for 14.9% of the country’s total population. In recent years, China’s birth rate and death rate are both decreasing, and people’s life expectancy is improving, which amplified the trend of the aging population. In addition, according to the National Health Commission of the People’s Republic of China, the elderly population aged 60 and above is expected to continue to grow from 2022 to 2035, and will reach 400 million in 2035, accounting for more than 30% of the total population in 2035. Therefore, elderly care has become a major problem that Chinese families urgently need to solve. As a result, it will provide the market opportunities for the development of the wellness and elderly care smart robotic products and services.

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### *Shortage of Long-term Care Workers*

China is facing an inevitable challenge in the shortage of long-term care workers and an increasingly aging population. Given the increasing labor costs and the expected relatively slow growth of the supply of long-term care workers, wellness and elderly care smart robots, which are capable of performing laborious and repetitive rehabilitation tasks and ensuring the accuracy and consistency of training movements, present themselves as a more efficient and effective approach to address the rapidly increasing demands on elderly care, and they could also fill the supply-demand gap of long-term workers in China.

### ***Market Trends of China’s Wellness and Elderly Care Smart Robotic Products and Services Industry***

#### *Gradually Increasing Market Share of Wellness and Elderly Care Smart Robots*

Triggered by the recent rapid development of technologies such as AI and IoT, the wellness and elderly care smart robots will serve as the intelligent products that integrate all the functions of simple and basic wellness and elderly care equipment and have the ability to perform intended tasks autonomously. Moreover, the rising aging population and the increasing number of empty-nest elderly families will make the future demand for wellness and elderly care smart robots grow strongly, especially the demand for wellness and elderly care smart robots with multiple functions such as rehabilitation, daily care, and medical care. As a result, there is much room for growth in wellness and elderly care smart robotic products and services market in the near future.

#### *Expansion of Wellness and Elderly Care Smart Robots in More Application Scenarios*

With the continuous enrichment of function categories such as observation and monitoring of health status, emotional and physical companion, assistance of rehabilitation training, and voice interaction, wellness and elderly care smart robots will begin to expand from the professional field to the general public. For example, from the perspective of application scenarios, it is being popularized by hospitals and professional elderly care institutions to age-friendly communities and individual families.

### ***Competitive Landscape of China’s Wellness and Elderly Care Smart Robotic Products and Services Industry***

According to Frost & Sullivan, China’s wellness and elderly care smart robotic products and services industry has a highly fragmented competition landscape with more than 40 market players and the top three market players accounted for approximately 15.0% market share of the industry in terms of revenue in 2022. According to Frost & Sullivan, there are still limited players with mature technologies as the wellness and elderly care smart robotic products and services industry in China is still at the early stage. As a result, it is difficult to identify the rest of the dominant market players in the industry in terms of revenue in 2022.



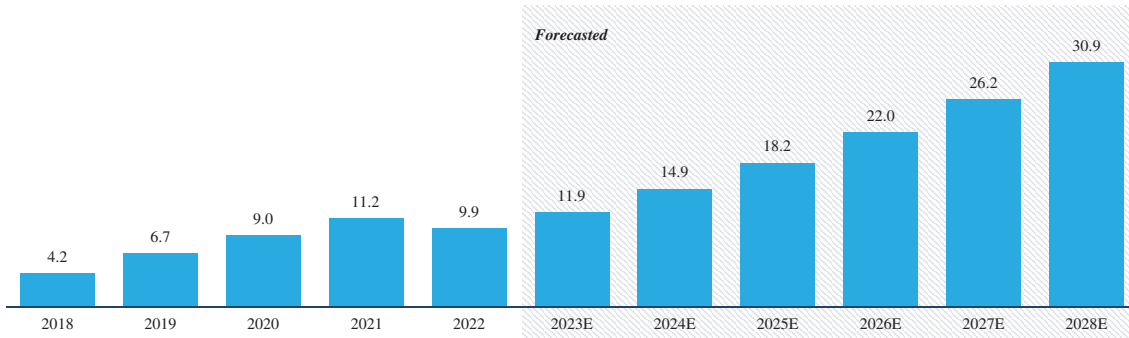
## INDUSTRY OVERVIEW

### Inspection Smart Robotic Products and Services Industry

#### *Market Size of China’s Inspection Smart Robotic Products and Services Industry*

RMB Billion, 2018-2028E

CAGR	2018-2022	2022-2028E
Inspection Smart Robots	23.9%	20.9%



Source: Interviews with industry players; Frost & Sullivan

Since the inspection smart robots can be used to detect faults or failure in the small or dangerous sites including pipelines, walls, and machines, it has been widely applied in the scenarios. In 2022, inspection smart robotic products and services market, measured by sales revenue, was valued at RMB9.9 billion, growing at a CAGR of 23.9% from 2018 to 2022, according to Frost & Sullivan. Due to the effect of COVID-19, it may be difficult for the suppliers to successfully deliver the products and services, as well as to meet the demand for inspection smart robotic products and services in China, as a result, there will be a slight decline in market size in 2022.

According to Frost & Sullivan, the main application scenarios of inspection smart robots are power distribution stations and substations, and the penetration rate of inspection smart robotic products and services is still relatively low since AI and robotic technologies are still quickly developing and inspection smart robots can only partially substitute or enhance manpower to finish works in some procedures. However, it is not feasible to calculate the penetration rate since different scenarios have varying needs for inspection smart robotic products and services.

In the forthcoming years, adoption of IoT, AI, and cloud computing will bring the advancement of the inspection smart robots. And the market size is anticipated to reach RMB30.9 billion by 2028, representing a CAGR of 20.9%, according to Frost & Sullivan.

#### ***Market Drivers of China’s Inspection Smart Robotic Products and Services Industry***

##### *Application requirements in dangerous sites*

It is well known that there are often inspection tasks in high-cold and remote areas and that people are usually unable to access, however inspection smart robots with advanced navigation technology can be used in substations and distribution plants in dangerous environments, gradually replacing personnel and collection systems. Examples include completing multiple inspections per day in unattended substations; reading and checking data and images, as well as other information from thousands of equipment inspection points.

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### *Development in AI Technology*

Currently, common technologies and features of inspection smart robotic products include magnetic rail navigation, laser navigation, differential GPS navigation and other positioning technologies. With the continuous development of AI technology, including the use of infrared technology to achieve navigation and positioning and visual recognition to achieve monitoring and monitoring, the inspection smart robotic products and services industry is constantly developing.

### *Policy Support from the National and Local Governments*

With policy support from both the national and local governments, China has achieved the early application of autonomous inspection smart robots in substations and other scenarios in the world. For example, with the support of the National “863 Program”, the State Grid Corporation of China has successively developed a series of substation inspection smart robots, which comprehensively use non-contact detection, multi-sensor fusion navigation and positioning, and visual servo pan-tilt control technologies to achieve inspections. The inspection smart robots are able to run autonomously outdoor under all climate conditions in all regions.

### ***Market Trends of China’s Inspection Smart Robotic Products and Services Industry***

#### *Maturity of Technologies such as Line Fault Detection*

With the gradual development of inspection smart robot technology, line fault detection methods and autonomous inspection technologies are gradually becoming more mature. Inspection smart robots will gradually integrate multiple sensors in future applications, and run multiple sensor fusion methods to cross obstacles to navigate and locate so that they can quickly realize fault judgment and positioning to ensure that the line can be restored to normal operating condition in a short time.

#### *Underlying Technology Needs to be Improved*

At present, the underlying technology of inspection smart robots, such as the accuracy of outdoor navigation technology, needs to be improved as it has become an important obstacle in restricting inspection smart robots’ large-scale application. Therefore, improving product reliability and truly realizing inspection robots’ potential in inspection and maintenance are the development goals of the inspection smart robotic products and services industry in the future.

#### *Integration of Multiple Work Methods*

The large size and limited flexibility of inspection smart robots often pose challenges during application process, especially when they need to perform a variety of task processing functions. Therefore, inspection smart robots in the future need to integrate multiple operating methods such as combining robot inspection and online monitoring technology, and be able to share information across systems and perform complex line inspection task.

### ***Competitive Landscape of China’s Inspection Smart Robotic Products and Services Industry***

According to Frost & Sullivan, China’s inspection smart robotic products and services industry has a highly fragmented competition landscape with more than 200 market players and the top five market players accounted for approximately 16.0% market share of the industry in terms of revenue in 2022. The company accounted for approximately 0.2% market share of the industry in terms of revenue in 2022.

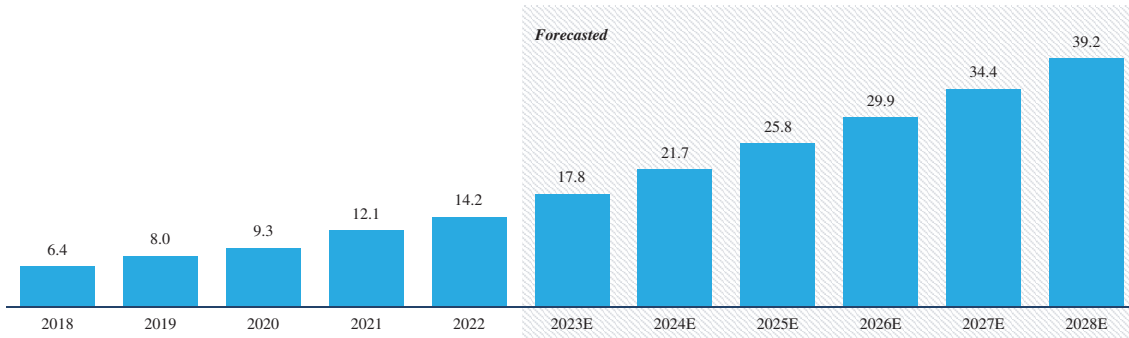
## INDUSTRY OVERVIEW

### Vacuum and Floor Cleaning Robotic Products Industry

#### Market Size of China’s Vacuum and Floor Cleaning Robotic Products Industry

RMB Billion, 2018-2028E

CAGR	2018-2022	2022-2028E
Vacuum and Floor Cleaning Robotic Products	22.0%	18.4%



Source: Interviews with industry players; Frost & Sullivan

Under the influence of fast-paced life, the emerging of vacuum and floor cleaning robots would satisfy the consumer’s demand for household cleaning. In 2022, vacuum and floor cleaning robotic products market, measured by sales revenue, has increased from RMB6.4 billion in 2018 to RMB14.2 billion in 2022, growing at a CAGR of 22.0% during this period, according to Frost & Sullivan.

According to Frost & Sullivan, the penetration rate of vacuum and floor cleaning robotic products industry in the PRC was less than 4% in 2022. Such penetration rate remains relatively low, mainly since: (1) compared to advanced economies, the average disposable income in the PRC remains relatively low, resulting in less availability for discretionary spending on non-essential items like vacuum and floor cleaning robots; (2) users are concerned about the reliability and maintenance of vacuum and floor cleaning robots.

Driven by the technological breakthroughs of essential technologies including AI, such as visual recognition, and SLAM, customers’ using experience will be highly enhanced, as a result, trigger the further growth of the market. In this regard, China’s vacuum and floor cleaning robotic products market is anticipated to reach RMB39.2 billion by 2028, representing a CAGR of 18.4% from 2022 to 2028, according to Frost & Sullivan.

#### Market Drivers of China’s Vacuum and Floor Cleaning Robotic Products Industry

##### The Prevalence of “Lazy Economy”

In today’s fast-paced environment, many consumers have no sufficient time for household chores, while the emergence of vacuum and floor cleaning robots are able to liberate consumers from household chores by providing autonomous cleaning services. In addition, people’s increasing pursuit of high-quality lifestyle increases as a result of economic development, which drives the growth of household products such as vacuum and floor cleaning robots.

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### *Enhancement in core technologies and quality of components*

The basic functions of vacuum and floor cleaning robots are sweeping, vacuuming, and mopping. Improvement in the quality of components such as the mopping cloth and water tank, and also in the technologies such as the rotation method of sweeping brushes that enable vacuum and floor cleaning robots to achieve higher quality and perform more functions. Moreover, cleaning routes of vacuum and floor cleaning robots have been transformed from random collision type to planning type to further enhance user experience, and thus driving the increasing demand for vacuum and floor cleaning robots.

### **Market Trends of China’s Vacuum and Floor Cleaning Robotic Products Industry**

#### *Diversified Product Technology Innovation Will Meet Consumers Need in Different Application Scenarios*

As technology continues to improve, consumer demand for the type of vacuum and floor cleaning robot will be more complex. The diversification of application scenarios will become the main development direction of the vacuum and floor cleaning robotic products industry. Moreover, major vacuum and floor cleaning robot manufacturers will actively launch various new products in the future, strengthen product technology innovation and AI development, and promote the diversification of product forms. Specifically, in the future, vacuum and floor cleaning robots will be able to collect information about cleaning areas, such as the structure of the house, the location of items, and user habits. The information collection capability combined with big data analysis, deep learning, and AI technology will enable vacuum and floor cleaning robots to provide diverse cleaning modes based on user preferences and provide personalized services, thereby greatly enhancing consumer experience to meet consumer needs in different application scenarios.

### **Competitive Landscape of China’s Vacuum and Floor Cleaning Robotic Products Industry**

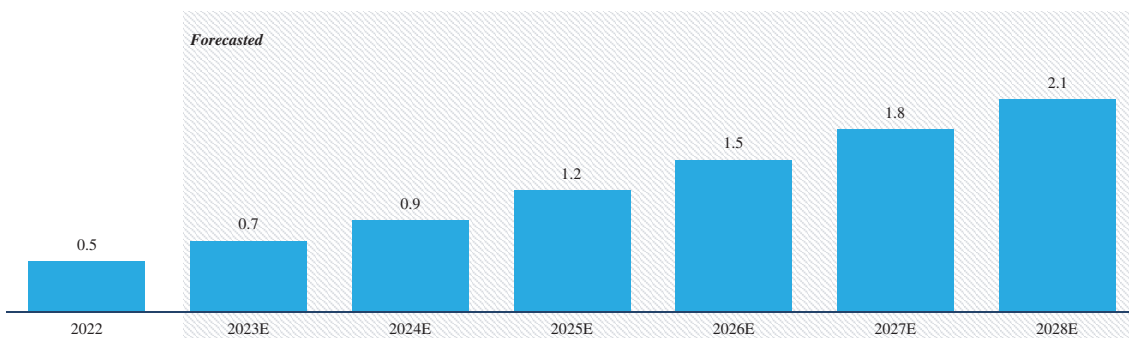
According to Frost & Sullivan, China’s vacuum and floor cleaning robotic products industry has a highly concentrated competition landscape with more than 20 major market players and the top five market players accounted for approximately 90.0% market share of the industry in terms of revenue in 2022. The company accounted for approximately 0.5% market share of the industry in terms of revenue in 2022.

### **Overview of China’s Reception Smart Robotic Products and Services Industry**

#### *Market Size of China’s Reception Smart Robotic Products and Services Industry*

RMB Billion, 2022-2028E

CAGR	2022-2028E
Reception Smart Robots	27.0%



Source: Interviews with industry players; Frost & Sullivan

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Reception smart robotic products and services market remained at a very early stage of commercialization in the past few years, however, driven by the pain points of high training costs and slow service response under traditional manual reception services, the acceptance of reception smart robots has increased. In 2022, the market size of China’s reception smart robotic products and services industry, measured by sales revenue, has reached RMB0.5 billion. According to Frost & Sullivan, due to the relatively high investment cost, the penetration rate of reception smart robotic products and services is still relatively low. While it is not feasible to calculate the penetration rate as reception smart robotic products and services can be widely applied in different scenarios with varying needs by customers. Looking forward, it is expected that the market size will steadily increase to RMB2.1 billion by 2028, representing a CAGR of 27.0% from 2022 to 2028, according to Frost & Sullivan.

### Competitive Landscape of China’s Reception Smart Robotic Products and Services Industry

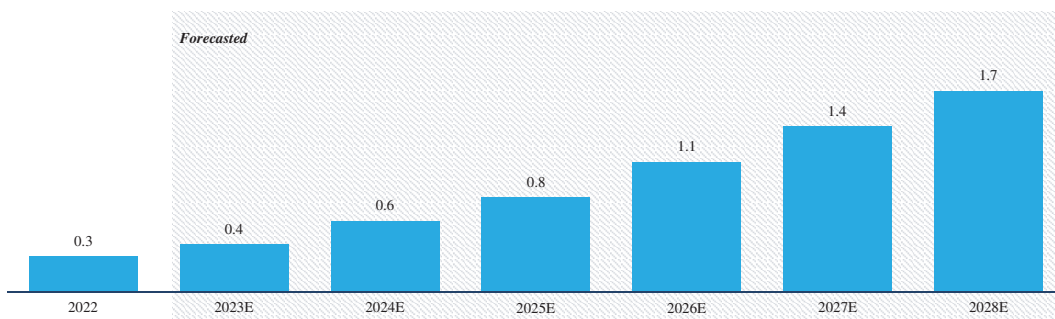
According to Frost & Sullivan, China’s reception smart robotic products and services industry is currently at the early stages of development and has a highly fragmented competition landscape. There are many market players that have the ability to provide reception smart robotic products and services, but none of them have emerged as dominant players in the market yet. According to Frost & Sullivan, the total number of the players in China’s reception smart robotic products and services industry is more than 50 in 2022, given the highly fragmented competitive landscape, it is difficult to identify the dominant market players. The company accounted for less than 15.0% market share of the industry in terms of revenue in 2022.

### Overview of China’s Food Delivery Smart Robotic Products and Services Industry

#### *Market Size of China’s Food Delivery Smart Robotic Products and Services Industry*

RMB Billion, 2022-2028E

CAGR	2022-2028E
Food Delivery Smart Robots	33.5%



Source: Interviews with industry players; Frost & Sullivan

Food delivery smart robotic products and services market remained at a very early stage of commercialization in the past few years, while triggered by the outbreak of COVID-19 and the popularity of contactless service, the market demand of food delivery smart robot in various scenarios including hotels and restaurants began to increase. In 2022, the market size of China’s food delivery smart robotic products and services, measured by sales revenue, has reached RMB0.3 billion. According to Frost & Sullivan, since the prices of food delivery smart robotic products and services are relatively high and primarily applied in large-scale chained-restaurants, the penetration rate of smart robotic products and services in the food delivery smart robotic products and services industry in the PRC was less than 1% in 2022. Looking forward, it is expected that the market size will steadily increase to RMB1.7 billion by 2028, representing a CAGR of 33.5% from 2022 to 2028, according to Frost & Sullivan.

## INDUSTRY OVERVIEW

### Competitive Landscape of China’s Food Delivery Smart Robotic Products and Services Industry

According to Frost & Sullivan, China’s food delivery smart robotic products and services industry is currently at the early stages of commercialization. The competition landscape is concentrated with more than 15 market players and the top three market players accounted for approximately 75.0% market share of the market share in terms of revenue in 2022.

#### Price range of smart service robot within key segments

The selling prices of smart service robots primarily depends on the functionalities that the robot can provide and the specifications of the robot. Smart service robots that can provide more functionalities are usually equipped with more components and advanced software, which lead to a higher price. For some smart service robots such as logistics and mobile robots, the selling price also depends on their load capacity. Smart service robots with higher load capacity usually have higher selling prices.

Segment of Smart Service Robot	Range of Selling Price in 2022 (in RMB Thousand)
Enterprise-level education robot	Between 3 ~ 10
Logistics and mobile robot	Between 50 ~ 800
Wellness and elderly care robot	Between 30 ~ 200
Inspection robot	Between 100 ~ 800
Vacuum and floor cleaning robot	Between 0.6 ~ 6
Reception robot	Between 8 ~ 60
Food delivery robot	Between 15 ~ 60
Consumer-level entertainment and companion robot	Between 0.1 ~ 6

*Note:* the selling price refers to the price that the end customers are charged.

*Source:* Frost & Sullivan

## OVERVIEW OF GLOBAL HUMANOID ROBOTIC PRODUCTS AND SERVICES INDUSTRY

### Definition of Humanoid Robots

A humanoid robot refers to a robot resembling the human body in shape and size and with the ability to mimic human motion, expressions, interaction, and movements. Humanoid robot is a relatively new type of smart service robot that is expected to form close relationship with human in daily routine and to replicate complex human motions.

### Core Technology of Humanoid Robots

#### *Servo Control*

High-performance Servo Actuator Control: can be used as a drive mechanism for the fingers and foot, providing precise and repeatable movements to achieve a wide range of flexible movements including walking, dancing, and push-up.

#### *AI Technologies*

Computer Vision: the technology that enables robots to identify and recognize faces, objects, and environments they encounter in a human-like vision, helping pick out details in objects for decision-making on their next actions motion, or interaction with human-being.

Voice Interaction: a comprehensive technology that uses voice as the basic information carrier to enable robots to interact with human-being in a human-like manner. It integrates technologies such as Automatic Speech Recognition (ASR), Natural Language Processing (NLP), and Text-to-speech (TTS).

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## INDUSTRY OVERVIEW

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### *Motion Planning and Control*

Motion planning refers to the method of motion tasks, and control is the process of execution. Motion planning and control ensure that the robot can accurately execute the given motion instructions, and realize functions such as operation, movement, and motion.

### **Market Size of Global Humanoid Robotic Products and Services Industry**

The humanoid robot can be utilized in a wide variety of scenarios, including serving as a receptionist, simulating human interaction for educational purpose, accompanying elderly as medical assistants, and rescuing employees from dangerous workplace activities. The global humanoid robotic products and services industry is still at early stage with a few market players and limited use scenarios. However, in the forthcoming years, technological advancement and increasing R&D investment in the industry will further drive the demand for humanoid robots and their commercialization. Furthermore, an increasing number of market players will enter the global humanoid robotic products and services industry, as a result, the global humanoid robotic products and services market is expected to reach USD9.5 billion in 2028, representing 15.2% of market size of global smart service robotic products and services industry, according to Frost & Sullivan. China’s humanoid robotic products and services market is expected to reach approximately RMB9.9 billion in 2028, representing approximately 5.4% of market size of China’s smart service robotic products and services industry, according to Frost & Sullivan.

### **Entry Barriers of Global Humanoid Robotic Products and Services Industry**

#### *Intensive Technical Requirements*

Compared with industrial robot and other type of smart service robot, the defining feature of bipedal humanoid robot is its kinematic structure. However, the current limited technology only allows for a simplified representation of the human form such as the legs. Since the humanoid robots are designed and manufactured with an anthropomorphic body to move flexibly within one complex terrain and mimic complex human motions and expressions, technological advancements are required for the development of humanoid robots.

#### *High R&D Expenses and Production Cost*

Unlike industrial robots and other type of smart service robots which are produced with mature technology and components widely available with competitive price, production of humanoid robots requires heavy R&D investment, high maintenance costs, complex components, and advanced technology. Thus high production cost and R&D expenses are one of the major entry barriers of the commercialization of humanoid robots.

### **Market Trends of Global Humanoid Robotic Products and Services Industry**

#### *Further Application Scenarios of Humanoid Robots with Technology Improvement*

With continuous R&D focusing on humanoid robot technologies and systems such as mechatronics, visual and haptic grasping and mobile manipulation, learning from human observation, modeling and analysis of human movements, humanoid robots are able to perform versatile tasks and better interact with humans. As a result, there will be an increasing applications of humanoid robots in various fields, such as education and entertainment, wellness and elderly care, disinfection, and logistics in the coming years.

#### *Commercialization of Humanoid Robots with Decreasing Production Costs*

The high production costs and R&D expenses of humanoid robots are major barriers for market growth. However, factors such as an aging population are expected to create huge opportunities for the adoption of the humanoid robots in the coming years, thus triggering the sales volume of humanoid robots. Moreover, the high cost of humanoid robots is attributed to complex application requirements and limitations in AI technology. Technologies such as vision processing and sensing technologies will support humanoid robots to make technological breakthroughs in areas such as maintaining good posture and gait, which will reduce costs and promote commercialization of humanoid robots in the near future.

## INDUSTRY OVERVIEW

### Overview of Major Players of Global Humanoid Robotic Products and Services Industry

According to Frost & Sullivan, the global humanoid robotic products and services industry remains at the early stages of technological exploration and development, with limited market players and yet to commercialize humanoid robots at a large scale. Moreover, some market players even have not commercialized their humanoid robots, and thus it is unable to identify the revenue generated from the humanoid robots. Within the very few market participants in the global humanoid robotic products and services industry, the table set forth below is an overview of the representative market players with years of research and development experience or brand awareness in the industry and have unveiled the prototype to the public.

Company	Overview	Listing Status	Geographical Coverage of Products	Number of employees (As of Dec 31, 2022)	Humanoid Robot	Released Year	Biped life-sized humanoid robot	Speed	Degrees of freedom <sup>1</sup>	Sales
UBTECH	<ul style="list-style-type: none"> <li>Founded in 2012, headquartered in Shenzhen, China. The company is an established smart service robotic products and services provider in China.</li> </ul>	• (REDACTED)	<ul style="list-style-type: none"> <li>China and over 50 overseas countries and regions</li> </ul>	<ul style="list-style-type: none"> <li>1,692</li> </ul>	<ul style="list-style-type: none"> <li>It is a biped life-sized humanoid robot that has been showcased in the China Pavilion of Dubai World Expo in 2021 to 2022.</li> </ul>	2018	√	3km/h	41	√
Boston Dynamics	<ul style="list-style-type: none"> <li>Founded in 1992, the company focuses on creating robots with advanced mobility, dexterity and intelligence. It is headquartered in Waltham, the USA.</li> </ul>	• Not listed	<ul style="list-style-type: none"> <li>United States, the European Union, United Kingdom, and Canada</li> </ul>	<ul style="list-style-type: none"> <li>Around 500</li> </ul>	<ul style="list-style-type: none"> <li>It initially designed for a variety of search and rescue tasks, and has one of the world’s most compact mobile hydraulic systems.</li> </ul>	2013	√	9km/h	28	/
Agility Robotics	<ul style="list-style-type: none"> <li>Founded in 2015, the company focused on the development of highly capable bipedal robots for applications that include logistics, telepresence, automated inspection, entertainment, and research. It is headquartered in Albany, the USA.</li> </ul>	• Not listed	<ul style="list-style-type: none"> <li>United States</li> </ul>	<ul style="list-style-type: none"> <li>Around 180</li> </ul>	<ul style="list-style-type: none"> <li>It has nimble limbs and a torso packed with sensors that will allow it to navigate complex environments and carry out tasks like package delivery.</li> </ul>	2002	√	5.4km/h	16	√
Honda <sup>2</sup>	<ul style="list-style-type: none"> <li>Founded in 1948, headquartered in Minato, Japan. The company is a manufacturer of automobiles, motorcycles, and power equipment.</li> </ul>	• Listed on the Tokyo Stock Exchange	<ul style="list-style-type: none"> <li>The United States, China, India, Indonesia, Thailand, the UK, Germany and Italy</li> </ul>	<ul style="list-style-type: none"> <li>Around 204,000</li> </ul>	<ul style="list-style-type: none"> <li>It is able to detect the movements of multiple objects by using visual information captured by two cameras in its head and recognize its surrounding environment, sounds and faces to interact with humans.</li> </ul>	2000	√	2.7km/h ~9km/h	57	√
XIAOMI	<ul style="list-style-type: none"> <li>Founded in 2010, headquartered in Beijing, China. The company is a consumer electronics and smart manufacturing company with smartphones and smart hardware connected by an IoT platform.</li> </ul>	• Listed on the HKEX	<ul style="list-style-type: none"> <li>China and over 100 overseas countries and regions</li> </ul>	<ul style="list-style-type: none"> <li>Around 32,500</li> </ul>	<ul style="list-style-type: none"> <li>It is a biped life-sized humanoid robot with artificial intelligence-based interaction algorithms that allows it to detect 45 classifications of human emotion and recognize 85 types of environmental sounds.</li> </ul>	2022	√	3.6km/h	21	/
Rainbow Robotics <sup>3</sup>	<ul style="list-style-type: none"> <li>Founded in 2011, headquartered in Daejeon, South Korea. It is a technological mechatronics company that engages in the development of robotic system engineering technology.</li> </ul>	• Listed on the KOSDAQ	<ul style="list-style-type: none"> <li>South Korea and the United States</li> </ul>	<ul style="list-style-type: none"> <li>Around 100</li> </ul>	<ul style="list-style-type: none"> <li>It is a full-size humanoid with a high-performance actuation system optimized for dynamic tasks, including walking, running, dancing, and grasping objects.</li> </ul>	2009	√	1.5km/h ~3.6km/h	40	√
KAWADA Robotics <sup>4</sup>	<ul style="list-style-type: none"> <li>Founded in 2013, headquartered in Tokyo, Japan. The company has developed its business through the development of humanoid robots that work with people.</li> </ul>	• Listed on the Tokyo Stock Exchange	<ul style="list-style-type: none"> <li>Japan</li> </ul>	<ul style="list-style-type: none"> <li>Not disclosed</li> </ul>	<ul style="list-style-type: none"> <li>It is a biped life-sized humanoid robot that can cooperate with humans in lifting heavy objects, walk on uneven surfaces, and even get up by itself if it falls over.</li> </ul>	2002	√	2km/h	30	√

#### Notes:

- Degrees of freedom of a robot refer to the independent joint that can provide freedom of movement and can be used to define the motion capabilities of robots.
- Honda ceased the commercial development of its humanoid robot in 2018.
- The humanoid robot of Rainbow Robotics was originally designed at the Korea Advanced Institute of Science and Technology (KAIST) in 2009 and commercialized by Rainbow Robotics.
- The humanoid robot of KAWADA Robotics was originally designed at the National Institute of Advanced Industrial Science and Technology (AIST) in 2002 and commercialized by KAWADA Robotics.

Source: Interviews with industry players; Frost & Sullivan



## INDUSTRY OVERVIEW

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The extent of the advancement comparisons of the Group’s and its peers’ humanoid robots are limited since (i) the industry benchmarks and standards available for comparison purposes are limited because the global humanoid robotic products and services industry remains at the early stages of technological exploration and development; and (ii) information regarding certain benchmarks and standards in relation to humanoid robots are not publicly available for comparison since not all comparable humanoid robots in the industry have been commercialized. Based on the aforementioned advancement comparison of the Walker X with the Group’s peers’ humanoid robots with reference to publicly available information of the humanoid robots of the Group’s peers, Frost & Sullivan believes that the core technologies and functionalities of Walker X (including, but not limited to, walking ability, balancing ability, operating ability, AI ability and autonomous ability) are comparable to those of the Group’s peers’ humanoid robots.