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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, an independent third-party industry consultant commissioned by us. The information derived from official government sources has not been independently verified by us, the Sole Sponsor, the [REDACTED], [REDACTED], [REDACTED] and [REDACTED], any of the [REDACTED], any of our and their respective directors, officers, representatives, employees or advisers, or any other persons or parties involved in the [REDACTED], and no representation is given as to its completeness, accuracy or fairness.*

### 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. Frost & Sullivan has independently verified the information, but the accuracy of the conclusions of its review largely relies on the accuracy of the information collected. Frost & Sullivan’s research may be affected by the accuracy of assumptions used and the choice of primary and secondary sources.

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 ROBOT-BASED SOLUTION INDUSTRY

As one of the most iconic tool 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 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 automation applications. 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 automation applications, 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.

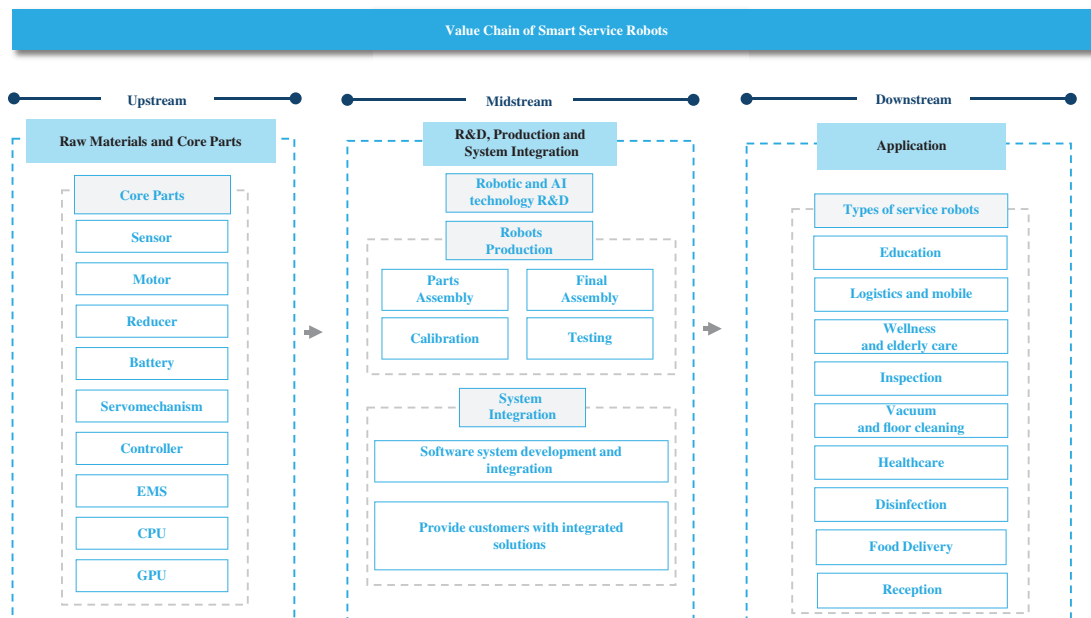
### Definition of Smart Service Robot and Smart Service Robot-based Solution

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 smart personal/domestic service robot and smart professional service robot. Smart personal/domestic service robot is a smart service robot used for non-commercial tasks, usually by lay persons, such as smart vacuum and floor cleaning robots, smart consumer-level education robot, smart entertainment robot, and smart personal mobility assist robot. Smart professional service robot is a smart service robot used for a commercial task, sometimes operated by a properly trained operator, such as enterprise-level smart education robot, smart logistics robot, smart food delivery robots, smart reception robots, smart inspection robots, and smart wellness and elderly care robot. The humanoid robots can be either smart professional service robots or smart personal/domestic service robots depending on the scenarios and objects they serve.

A smart service robot-based solution refers to a solution which is smart service robot-centric and integrates necessary peripheral hardware and software products and services to perform intended tasks.

### 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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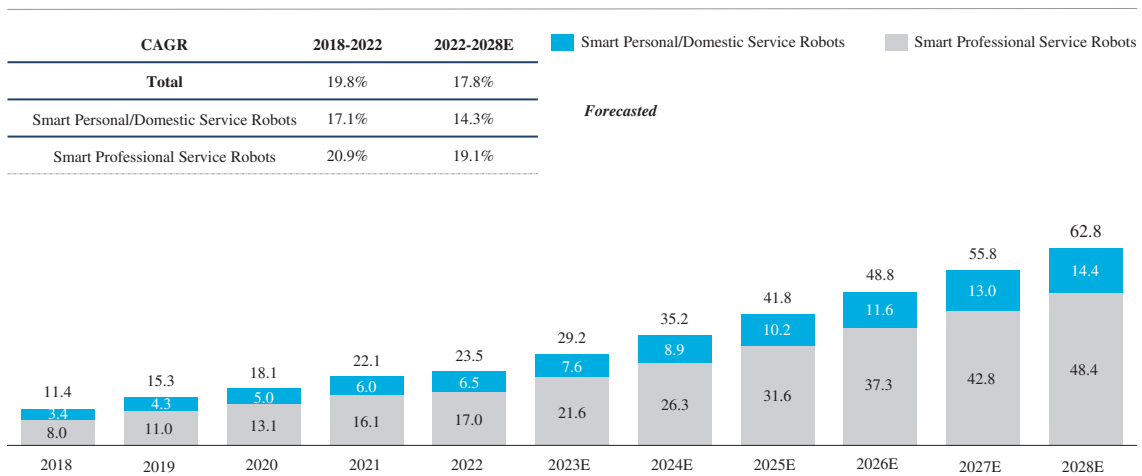
### Core Technologies of Smart Service Robots

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

<b>Computer Vision</b>	<ul style="list-style-type: none"> <li>Computer vision technologies enable 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 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 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 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 robot to accurately execute the given motion instructions, and realize functions such as operation, movement, and motion</li> </ul>

### Market Size of Global Smart Service Robot-based Product and Solution Industry

USD Billion, 2018-2028E



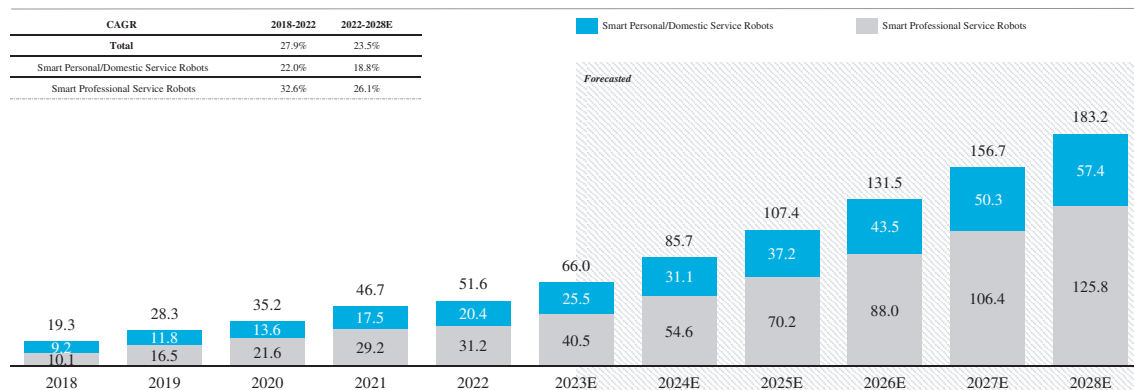
Source: International Federation of Robotics; Frost & Sullivan

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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 robot price, and the gradually increasing willingness of downstream customers to accept paying for smart service robot-based solution as robot-based solution become more widely adopted in more use scenarios accelerate the fast growth of global smart service robot-based product and solution market. Moreover, labor shortage and increasing labor costs further accelerated the fast penetration of smart service robot-based product and solution. According to Frost & Sullivan, the global smart service robot-based product and solution 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 solutions expand and become more mature and flexible, it is expected that the market size of global smart service robot-based product and solution 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 Robot-based Product and Solution Industry



Source: International Federation of Robotics; Frost & Sullivan

China’s government has launched a series of favorable policies, such as “The “Robot +” Application Action Implementation Plan” 《“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 robot industry have formulated an aggregation and synergistic effect. Moreover, the strong market demand in China provides more opportunities and confidence for robot companies to launch innovative solutions. According to Frost & Sullivan, China’s smart service robot-based product and solution 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 robotic products and solutions in the smart service robot-based industry in the PRC remained low in recent years. The low penetration rate of robot services adoption can be attributed to several factors, including: High cost: Robotic services can be expensive to develop and deploy, making them unaffordable for many businesses and consumers. Limited functionality: Many robotic services have limited functionality and are not yet capable of performing complex tasks that humans can do, making them less attractive to potential users. Lack of awareness: Many businesses and consumers are not aware of the potential benefits of using robotic services, or they may not understand how to use them effectively. Technical challenges: Developing and deploying robotic 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 robot-based product and solution market significantly in the next few years, and the use scenarios of smart service robot-based product and solutions in China will be further explored. Moreover, the continuous upgrades of appearance and functionality of personal/domestic use smart service robots for non-commercial tasks as well as the compelling application at a competitive price will further stimulate the growth of smart personal/domestic service robot product and solution market. According to Frost & Sullivan, China’s smart service robot-based product and solution market will reach RMB183.2 billion with a CAGR of 23.5% from 2022 to 2028.

### **Market Drivers of China’s Smart Service Robot-based Solution Industry**

#### ***Favorable Policies to Propel the Development of China’s Smart Service Robot-Based Solution Industry***

The smart service robotic solutions industry is considered by the Chinese government as an important industry, and the Chinese government has promulgated a series of favorable policies to propel the development of the smart service robot-based solution 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 “The “Robot +” Application Action Implementation Plan” 《“机器人+”应用行动方案》, which proposes that the depth and breadth of application of service robots and special robots in the industry is expected to significantly increase, which would benefit various industries including, among others, manufacturing, agricultural, construction, energy, logistics; and that 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 robots to address the challenges associated with labor shortage and increasing labor costs.

### **Advancement of Core Technologies in Smart Service Robot-based Solution Industry**

Previous service robot-based solutions, 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 service robot-based solutions. 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 robot-based solution 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 the flexible and precise movements of smart robots. The advancement of AI technologies transformed robots from passive interaction to active interaction with human, addresses limitations of traditional service robot-based solutions.

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### ***Increasing Consumer Acceptance of Smart Service Robot-based Solutions***

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 robot-based solutions to increase work efficiency and safety. Hence, for the past several years, smart service robot-based solution 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 Robot-based Solution 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 develop various robot-based applications (such as making coffee, bringing a chair, fetching medicine) much easier, without learning 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 Robot-based Solution 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, robots and AI technologies have enabled innovative solutions to the challenges faced by businesses of all sizes. Companies are using AI robots to bring humans and technology closer together, solve problems, and transform their business models to meet changing 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 “Solutions (Products + Services)”***

With the deeper understanding of industry pinpoint and the further development of robot technologies, robot companies nowadays are able to provide robot-centric solutions instead of single product. For instance, professional 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 robot companies, the proliferation of integrated solutions which contains 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 low application cost advantages of modular technology design has been fully reflected in R&D and production of smart service robots.

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### Entry Barriers of China’s Smart Service Robot-based Solution Industry

#### *Accumulation of AI and Robotic Technologies*

Artificial Intelligent is a new and complicated technologies, requires the robot company accumulates great number of technical reserves, the new entrants are hard to gather technical reserves to achieve mature AI technology. Moreover, the capability of combining the hardware and software together, such as the fusion of perception and motion control, is another technical barrier that only a few robot companies could realize.

#### *Sufficient Industry Know-how*

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

#### *Intensive and Continuous R&D Investment*

R&D are imperative to withstand competition, waves of technological disruption, and obsolescence. For robot companies, investing in cutting-edge technologies, and talents are essential to the innovation of their products and services. As mainstream products in the market continue to be more intelligent, the market share of lower-end and less intelligent and innovative products produced by small or start-up enterprises with low R&D levels will be reduced.

## COMPETITIVE LANDSCAPE OF CHINA’S SMART SERVICE ROBOT-BASED SOLUTION INDUSTRY

### Overview of Major Players

The competition of China’s smart service robot-based solution industry is intense. However, 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. According to Frost & Sullivan, we ranked 3rd in China’s smart service robot-based solution industry in terms of revenue in 2022 and we are one of the two companies among top five that have full-stack technologies capabilities. The following table illustrates the information of top five players:

Ranking	Company	Overview	Registered Capital (RMB Million)	[REDACTED] Status	Geographical Coverage of Products	Type of smart service robot	Fullstack core technologies	Revenue of smart service robot-based solution in China 2022 (RMB, Billion)	Market share in 2022
1	Company A	<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	Smart public service robot	✓	2.0	6.4%
2	Company B	<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	Smart logistics 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 service robotics products and solutions provider in China</li> </ul>	407	[REDACTED]	China and over 50 overseas countries and regions	<ul style="list-style-type: none"> <li>Smart education robot</li> <li>Smart logistics robot</li> <li>General service robot</li> </ul>	✓	0.9	2.8%
4	Company C	<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	Smart inspection robot	/	0.9	2.7%
5	Company D	<ul style="list-style-type: none"> <li>Founded in 2015, headquartered in Beijing China. It is a solution provider in the smart logistics and mobile robotic industry.</li> </ul>	1,159	Not listed	China, and over 40 overseas countries and regions	Smart logistics 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 not a specific price trend for the raw materials of the raw materials of the products of the Group. Given the variety of raw materials of a smart service robot, the correlation of robot product 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 ROBOT-BASED SOLUTION INDUSTRY IN CHINA BY USE SCENARIOS

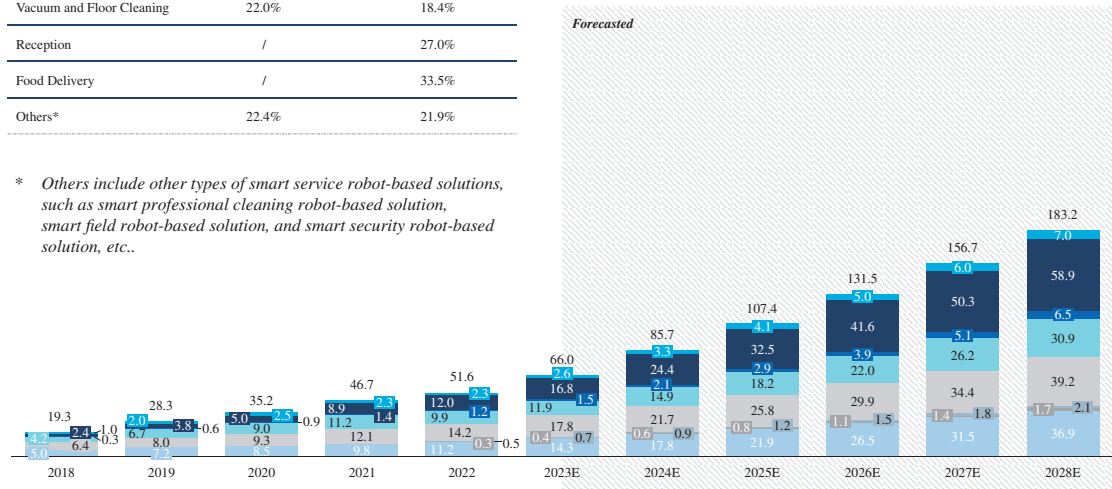
#### The Breakdown of Market Revenue of Smart Service Robot-Based Solution in China by Key Segments

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%

- Smart Education Robot-based Solution
- Smart Logistics and Mobile Robot-based Solution
- Smart Wellness and Elderly Care Robot-based Solution
- Smart Inspection Robot-based Solution
- Smart Vacuum and Floor Cleaning Robot Product
- Smart Reception Robot-based Solution
- Smart Food Delivery Robot-based Solution
- Others

\* Others include other types of smart service robot-based solutions, such as smart professional cleaning robot-based solution, smart field robot-based solution, and smart security robot-based solution, etc..



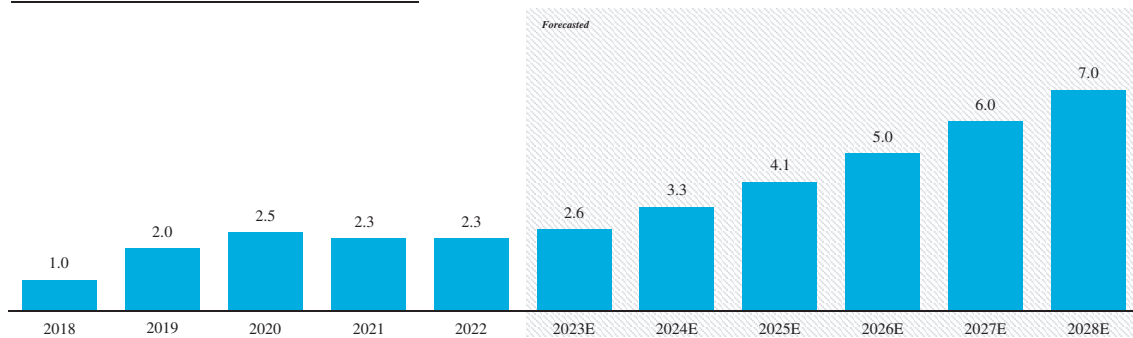
Source: International Federation of Robotics; Frost & Sullivan

### Smart Education Robot-based Solution Industry

#### Market Size of China's Smart Education Robot-based Solution Industry

RMB Billion, 2018-2028E

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



Source: Interviews with industry players; Frost & Sullivan

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Smart education robot-based solutions (i) mean educational robotic products and solutions that utilize any AI technologies, rather than the common hardware including computers and projectors, used in the teaching process; (ii) consist of smart education 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 smart education robot-based solution, 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 smart education robot-based solution 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 smart education 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 robotic products and solutions in the smart education robot-based solution 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 robotic products and solutions in smart education robot-based solution industry in the PRC; and (ii) the adoption of smart robotic products and solutions 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 robot-based solution 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 Smart Education Robot-based Solution Industry***

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

Policy support is a major factor of the rapid development of China’s smart education robot-based solution 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 smart educational 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 smart education 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 with traditional teaching and learning scenarios, innovative teaching modes by having various enrichment learning and teaching classes including AI has broken the conventional restrictions, thereby significantly cultivate the comprehensive literacy of generation Z or post-00s, and empowered the interactive and technical teaching process. Therefore, the prevalence of such innovation in the teaching steps drives the growth of the smart education robot-based solution industry.

### **Market Trends of China’s Smart Education Robot-based Solution Industry**

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

Benefiting from the continuous development of machine learning, AI, and other technologies, smart education robot 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 an educational tools for learning purpose. Furthermore, in order to enhance the learning and using experience supported by smart education 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.

#### *Robot education enters more and more schools and educational institutions*

At the present stage, programme writing educational 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, smart educational robots will gradually enter more and more schools and educational institutions to cultivate students’ comprehensive ability in an all-round way and improve their competitiveness.

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### Competitive Landscape of China’s Smart Education Robot-based Solution Industry

According to Frost & Sullivan, the competitive landscape of China’s smart education robot 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 smart education robot-based solution industry:

Ranking	Company	Overview	[REDACTED] Status	Geographical Coverage of Products	Number of employees (As of Dec 31, 2022)	Introduction of education robot-based solutions	Sales revenue of education robot-based solution 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 service robotics products and solutions provider in China.</li> </ul>	<ul style="list-style-type: none"> <li>[REDACTED]</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>1,692</li> </ul>	<ul style="list-style-type: none"> <li>It engages in provision of education robotic solutions in both enterprise-level and consumer-level.</li> </ul>	<ul style="list-style-type: none"> <li>517</li> </ul>	<ul style="list-style-type: none"> <li>22.5%</li> </ul>
2	Company E	<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>	<ul style="list-style-type: none"> <li>Listed on the Shenzhen Stock Exchange</li> </ul>	<ul style="list-style-type: none"> <li>China, Israel</li> </ul>	<ul style="list-style-type: none"> <li>Around 3,300</li> </ul>	<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 smart education robots.</li> </ul>	<ul style="list-style-type: none"> <li>92</li> </ul>	<ul style="list-style-type: none"> <li>4.0%</li> </ul>
3	Company F	<ul style="list-style-type: none"> <li>Founded in 2018, headquartered in Shanghai, China. The company is a robotics solution provider for the youth education.</li> </ul>	<ul style="list-style-type: none"> <li>Not listed</li> </ul>	<ul style="list-style-type: none"> <li>China and over 26 countries and regions</li> </ul>	<ul style="list-style-type: none"> <li>Around 100</li> </ul>	<ul style="list-style-type: none"> <li>It provides smart education robots, programmable robotics kits, or other educational robot-based services for schools and competitions.</li> </ul>	<ul style="list-style-type: none"> <li>52</li> </ul>	<ul style="list-style-type: none"> <li>2.2%</li> </ul>
4	Company G	<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>	<ul style="list-style-type: none"> <li>Not listed</li> </ul>	<ul style="list-style-type: none"> <li>China, the United States, Germany, the Netherlands, Japan, South Korea</li> </ul>	<ul style="list-style-type: none"> <li>Around 14,000</li> </ul>	<ul style="list-style-type: none"> <li>It provides a wide range of smart education robot-based solutions for learners.</li> </ul>	<ul style="list-style-type: none"> <li>50</li> </ul>	<ul style="list-style-type: none"> <li>2.2%</li> </ul>
5	Company H	<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>	<ul style="list-style-type: none"> <li>Not listed</li> </ul>	<ul style="list-style-type: none"> <li>China and over 140 countries and regions</li> </ul>	<ul style="list-style-type: none"> <li>More than 500</li> </ul>	<ul style="list-style-type: none"> <li>It provides smart educational products and solutions, such as robotic kits and robot-based teaching resources for schools.</li> </ul>	<ul style="list-style-type: none"> <li>45</li> </ul>	<ul style="list-style-type: none"> <li>2.0%</li> </ul>

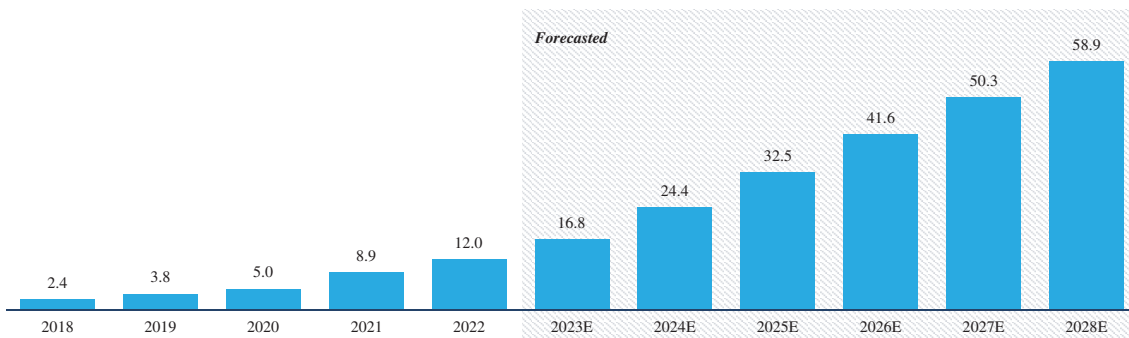
Source: Interviews with industry players; Frost & Sullivan

### Smart Logistics and Mobile Robot-based Solution Industry

#### Market Size of China’s Smart Logistics and Mobile Robot-based Solution Industry

RMB Billion, 2018-2028E

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



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

Driven by a rising application scenarios of smart logistics and mobile robots such as warehouse picking and distribution, according to Frost & Sullivan, the market size of China’s smart logistics and mobile robot-based solution, 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 smart logistics and mobile robot-based solutions industry in the PRC is still relatively low, since: (1) it takes time for end customers with different business scales and the willingness of digital transformation to adopt and pay for such products and solutions; (2) there is a high initial investment cost required for customers to transform traditional factories into smart factories. Moreover, as smart logistics and mobile robot-based solutions 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 smart logistics and mobile robot-based solutions.

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 smart logistics and mobile robot-based solution 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 Smart Logistics and Mobile Robot-based Solution 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 smart logistics and mobile robot-based solutions.

#### *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 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 robots to replace labor.

### ***Market Trends of China’s Smart Logistics and Mobile Robot-based Solution Industry***

#### *Further Demand of Smart Robotic Solutions in Warehousing and Production Process*

Market participants in manufacturing businesses which adopt smart robotic solutions 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 smart robotic solutions 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 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.

## INDUSTRY OVERVIEW

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

The design of logistics robot 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 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 Smart Logistics and Mobile Robot-based Solutions 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 smart logistics and mobile robot-based solutions 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 Smart Logistics and Mobile Robot-based Solution Industry**

According to Frost & Sullivan, China’s smart logistics and mobile robot-based solution industry is fragmented with more than 50 market players and the top five market players accounted for 31.9% 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 smart logistics and mobile robot-based solution industry in terms of revenue in 2022. The table set forth below illustrates the information of the top five market players in China’s smart logistics and mobile robot-based solution industry:

Ranking	Company	Overview	[REDACTED] Status	Geographical Coverage of Products	Number of employees (As of Dec 31, 2022)	Introduction of logistics and mobile robot-based solutions	Sales revenue of logistics and mobile robot -based solution in China in 2022 (RMB, million)	Market share in 2022
1	Company B	<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 smart mobile robots and systems, and build smart internal logistics solutions in industrial factories.</li> </ul>	<ul style="list-style-type: none"> <li>1,450</li> </ul>	<ul style="list-style-type: none"> <li>12.1%</li> </ul>
3	Company D	<ul style="list-style-type: none"> <li>Founded in 2015, headquartered in Beijing, China. It is a solution provider in the smart logistics and mobile robotic 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 robot-based (AMRs) solutions 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>
4	Company I	<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 smart logistics and distribution solutions 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>
5	Company J	<ul style="list-style-type: none"> <li>A public company founded in 2007, headquartered in Hefei, China. The company is a comprehensive solutions provider in the smart manufacturing and smart logistics 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 solutions 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	Company K	<ul style="list-style-type: none"> <li>Founded in 2016, headquartered in Shenzhen, China. The company is a smart logistics robotic solutions 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 solutions 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

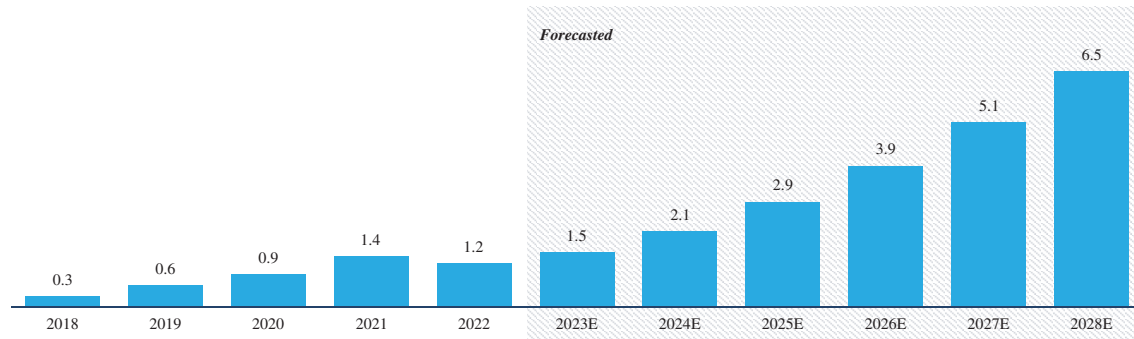
## INDUSTRY OVERVIEW

### Smart Wellness and Elderly Care Robot-based Solution Industry

#### Market Size of China’s Smart Wellness and Elderly Care Robot-based Solution Industry

RMB Billion, 2018-2028E

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



Source: Interviews with industry players; Frost & Sullivan

According to Frost & Sullivan, China’s smart wellness and elderly care robot-based solution 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 smart wellness and elderly care robots has increased.

According to Frost & Sullivan, the penetration rate of smart wellness and elderly care robot-based solution 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 smart wellness and elderly care robot-based solutions, leading to low penetration rates. However, it is difficult to identify the total number of customers as smart wellness and elderly care robot-based solutions 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 smart wellness and elderly care robot-based solutions.

Looking forward, driven by the advancement of the technologies and the iteration of sensors, the smart wellness and elderly care robots will be commercialized, and also there is much room for growth in smart wellness and elderly care robot-based solution 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 Smart Wellness and Elderly Care Robot-based Solution 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 smart wellness and elderly care robot-based solutions.

## INDUSTRY OVERVIEW

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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, smart wellness and elderly care 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 Smart Wellness and Elderly Care Robot-based Solution Industry***

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

Triggered by the recent rapid development of technologies such as AI and IoT, the smart wellness and elderly care 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 smart wellness and elderly care robots grow strongly, especially the demand for smart wellness and elderly care robots with multiple functions such as rehabilitation, daily care, and medical care. As a result, there is much room for growth in smart wellness and elderly care robot-based solution market in the near future.

#### *Expansion of Smart Wellness and Elderly Care 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, smart wellness and elderly care 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 Smart Wellness and Elderly Care Robot-based Solution Industry**

According to Frost & Sullivan, China’s smart wellness and elderly care robot-based solution 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 smart wellness and elderly care robot-based solution 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.



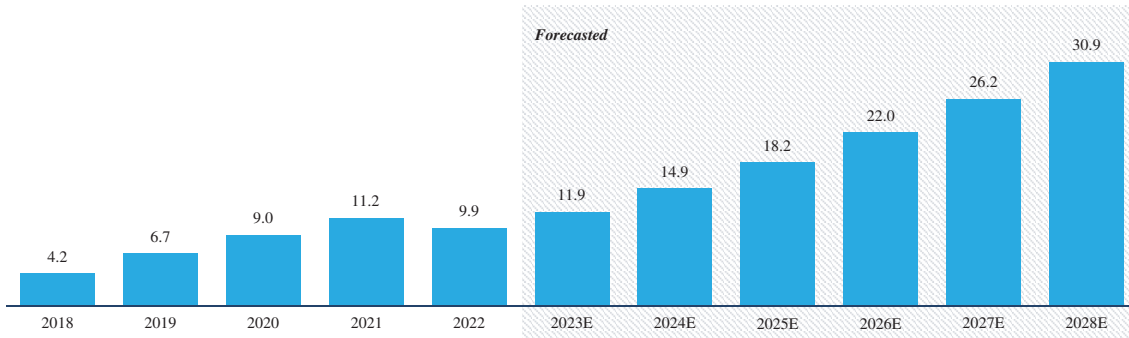
## INDUSTRY OVERVIEW

### Smart Inspection Robot-based Solution Industry

#### *Market Size of China’s Smart Inspection Robot-based Solution Industry*

RMB Billion, 2018-2028E

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



Source: Interviews with industry players; Frost & Sullivan

Since the smart inspection 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, smart inspection robot-based solution 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 smart inspection robot-based solutions 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 smart inspection robots are power distribution stations and substations, and the penetration rate of smart inspection robot-based products and solutions is still relatively low since AI and robotic technologies are still quickly developing and smart inspection 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 smart inspection robot-based solutions.

In the forthcoming years, adoption of IoT, AI, and cloud computing will bring the advancement of the inspection 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 Smart Inspection Robot-based Solution 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 smart inspection 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.

##### *Development in AI Technology*

Currently, common technologies and features of inspection robot 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 robot industry is constantly developing.

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## INDUSTRY OVERVIEW

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### *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 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 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 robots are able to run autonomously outdoor under all climate conditions in all regions.

### **Market Trends of China’s Smart Inspection Robot-based Solution Industry**

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

With the gradual development of intelligent inspection robot technology, line fault detection methods and autonomous inspection technologies are gradually becoming more mature. Intelligent inspection 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 robots, such as the accuracy of outdoor navigation technology, needs to be improved as it has become an important obstacle in restricting inspection robots’ large-scale application. Therefore, improving product reliability and truly realizing inspection robots’ potential in inspection and maintenance are the development goals of the intelligent inspection robot industry in the future.

#### *Integration of Multiple Work Methods*

Intelligent inspection robots’ large size and poor flexibility often cause problems during application process if they possess a variety of task processing functions. Therefore, inspection 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 Smart Inspection Robot-based Solution Industry**

According to Frost & Sullivan, China’s smart inspection robot-based solution 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.

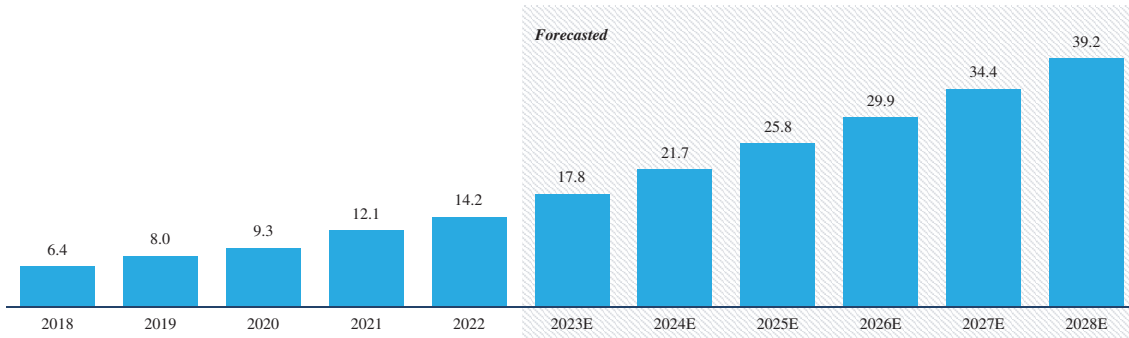
## INDUSTRY OVERVIEW

### Smart Vacuum and Floor Cleaning Robot Products Industry

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

RMB Billion, 2018-2028E

CAGR	2018-2022	2022-2028E
Smart Vacuum and Floor Cleaning Robot 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, smart vacuum and floor cleaning robot 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 smart vacuum and floor cleaning 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 smart vacuum and floor cleaning robots; (2) users are concerned about the reliability and maintenance of smart 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 smart vacuum and floor cleaning robot 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 Smart Vacuum and Floor Cleaning Robot 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 smart 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 smart vacuum and floor cleaning robots.

## INDUSTRY OVERVIEW

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

The basic functions of smart 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 smart vacuum and floor cleaning robots to achieve higher quality and perform more functions. Moreover, cleaning routes of 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 smart vacuum and floor cleaning robots.

### **Market Trends of China’s Smart Vacuum and Floor Cleaning Robot 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 smart vacuum and floor cleaning robot will be more complex. The diversification of application scenarios will become the main development direction of the smart vacuum and floor cleaning robot products industry. Moreover, major smart 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, smart 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 smart 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 Smart Vacuum and Floor Cleaning Robot Products Industry**

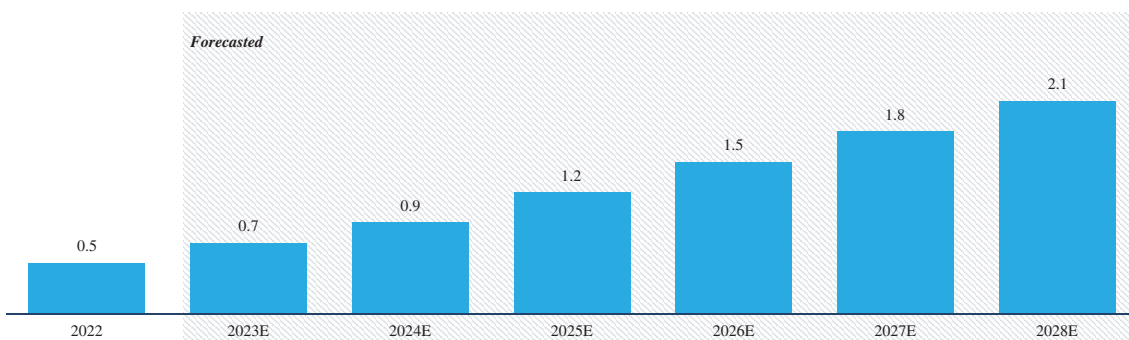
According to Frost & Sullivan, China’s smart vacuum and floor cleaning robot products industry has a highly concentrated competition landscape with more than 20 major market players and the top five market players accounted for approximately 90.0% market share of the industry in terms of revenue in 2022.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

### **Overview of China’s Smart Reception Robot-based Solution Industry**

#### **Market Size of China’s Smart Reception Robot-based Solution Industry**

RMB Billion, 2022-2028E

CAGR	2022-2028E
Smart Reception Robots	27.0%



Source: Interviews with industry players; Frost & Sullivan

## INDUSTRY OVERVIEW

Smart reception robot-based solution 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 smart reception robots has increased. In 2022, the market size of China’s smart reception robot-based solutions, measured by sales revenue, has reached RMB0.5 billion. According to Frost & Sullivan, due to the relatively high investment cost, the penetration rate of smart reception robot-based solutions is still relatively low. While it is not feasible to calculate the penetration rate as smart reception robot-based solutions 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 Smart Reception Robot-based Solution Industry

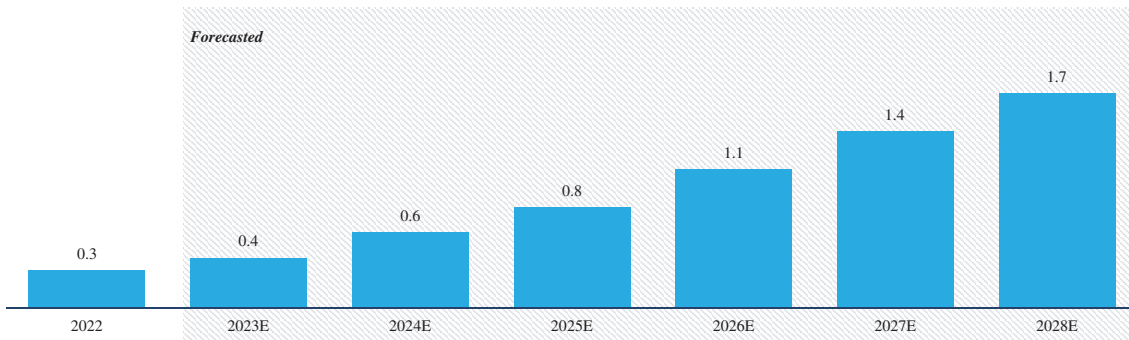
According to Frost & Sullivan, China’s smart reception robot-based solution industry is currently at the early stages of development and has a highly fragmented competition landscape. There are many market players that have the ability to provide smart reception robot-based solutions, but none of them have emerged as dominant players in the market yet. According to Frost & Sullivan, the total number of the players in China’s smart reception robot-based solution 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 Smart Food Delivery Robot-based Solution Industry

#### *Market Size of China’s Smart Food Delivery Robot-based Solution Industry*

RMB Billion, 2022-2028E

CAGR	2022-2028E
Smart Food Delivery Robots	33.5%



Source: Interviews with industry players; Frost & Sullivan

Smart food delivery robot-based solution 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 smart food delivery robot in various scenarios including hotels and restaurants began to increase. In 2022, the market size of China’s smart food delivery robot-based solutions, measured by sales revenue, has reached RMB0.3 billion. According to Frost & Sullivan, since the prices of smart food delivery robot-based solutions are relatively high and primarily applied in large-scale chained-restaurants, the penetration rate of robotic solutions in the smart food delivery robot-based solution 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 Smart Food Delivery Robot-based Solution Industry

According to Frost & Sullivan, China’s smart food delivery robot-based solution 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. Robots that can provide more functionalities are usually equipped with more components and advanced software, which lead to a higher price. For some robots such as logistics and mobile robots, the selling price also depends on their load capacity. 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 ROBOT-BASED SOLUTION 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 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 Robot-based Solution 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 robot-based 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 humanoid robot-based solution industry, as a result, the global humanoid robot-based solution market is expected to reach USD9.5 billion in 2028, representing 15.2% of market size of global smart service robot-based solution industry, according to Frost & Sullivan. China’s humanoid robot-based solution market is expected to reach approximately RMB9.9 billion in 2028, representing approximately 5.4% of market size of China’s smart service robot-based solution industry, according to Frost & Sullivan.

### **Entry Barriers of Global Humanoid Robot-based Solution 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 Robot-based Solution 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 Falling Production Costs*

It is accepted that 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 Robot-based Solution Industry

According to Frost & Sullivan, the global humanoid robot-based solution 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 robot-based 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	[REDACTED] 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 service robotics products and solutions provider in China.</li> </ul>	<ul style="list-style-type: none"> <li>[REDACTED]</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>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	√
Company M	<ul style="list-style-type: none"> <li>Founded in 2003, headquartered in Austin, the USA. The company is an automotive and clean energy company.</li> </ul>	<ul style="list-style-type: none"> <li>Listed on the NASDAQ</li> </ul>	<ul style="list-style-type: none"> <li>United States, and over 40 countries</li> </ul>	<ul style="list-style-type: none"> <li>Around 127,000</li> </ul>	<ul style="list-style-type: none"> <li>It will be controlled by the same AI system the company is developing for the advanced driver-assistance system used in its cars and have a carrying capacity of 45 lbs. (20kg). The prototype was showcased on the company's 2022 AI day.</li> </ul>	2022	√	8km/h	28+11 (hands)	/
Company N	<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>	<ul style="list-style-type: none"> <li>Not listed</li> </ul>	<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	/
Company O	<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>	<ul style="list-style-type: none"> <li>Not listed</li> </ul>	<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	√
Company P <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>	<ul style="list-style-type: none"> <li>Listed on the Tokyo Stock Exchange</li> </ul>	<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	√
Company Q	<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>	<ul style="list-style-type: none"> <li>Listed on the HKEX</li> </ul>	<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	/
Company R <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>	<ul style="list-style-type: none"> <li>Listed on the KOSDAQ</li> </ul>	<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	√
Company S <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>	<ul style="list-style-type: none"> <li>Listed on the Tokyo Stock Exchange</li> </ul>	<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.
- Company P ceased the commercial development of its humanoid robot in 2018.
- The humanoid robot of Company R was originally designed at the Korea Advanced Institute of Science and Technology (KAIST) in 2009 and commercialized by Company R.
- The humanoid robot of Company S was originally designed at the National Institute of Advanced Industrial Science and Technology (AIST) in 2002 and commercialized by Company S.

Source: Interviews with industry players; Frost & Sullivan