

Humanoid Robotics Industry Research Report

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1. Introduction

1.1 Overview of the Humanoid Industry

Humanoid robots are machines designed to **resemble and mimic human-like characteristics**, including **appearance, movement, and behavior**. These robots interact and collaborate with humans across various domains, including **manufacturing, industrial operations, customer service, research and development, healthcare, disaster response, space exploration, and domestic assistance**. With such a broad range of applications, humanoid robots have the potential to revolutionize industries, enhance productivity, and reshape human-technology interactions.

As GenAI transitions from the digital world to the physical world, humanoid robots hold immense potential for development and growth. Currently, **73%** of companies involved in humanoid robot development are based in Asia, with **56%** of this group in China. As of July 2023, China has over **190,000 effective robot-related patents**, accounting for approximately **two-thirds** of the global total.

1.2 Industry Drivers

The growth of the humanoid robot industry is primarily driven by **advancements in hardware, improvements in AI algorithms, lower production costs, and rising demand in the labor market**. According to Goldman Sachs, current **hardware** capabilities are sufficient to support humanoid robot construction, and rapid progress in **end-to-end AI** is expected to accelerate iterations. By integrating AI-driven decision-making with physical-world execution, robotics is evolving from rigid automation to intelligent, autonomous systems capable of real-world interaction and adaptation. Additionally, **decreasing costs** suggest faster commercialization of humanoid robots.

A notable trend involves companies from the **Electric Vehicle (EV) industry** expanding into humanoid robotics. This shift is driven by reduced profit margins in the EV sector and the advantages these companies possess in the new field, including **strong supply chains, scaled manufacturing, and experience in cutting-edge technologies**. The **technological overlap** between EVs and humanoid robotics is evident, as both depend on **environmental perception, interaction, and sensor-based data processing**. Lidar and depth cameras, initially designed for autonomous vehicles, are now being adapted for robotics. Additionally, EV-based **battery packs** can enable long operational runtimes. Currently, EV makers BYD and

XPeng are cooperating with Unitree, Nio has partnered with UBTech, and GAC Group has developed the GoMate robot for extended factory and warehouse operations.

1.3 China's Growing Dominance in the Industry

Over the past decade, China has experienced rapid growth in humanoid robotics, solidifying its position as the world's largest robotics market. According to **the World Robotics 2024 Report** by the International Federation of Robotics (IFR), China accounted for **51%** of global industrial robot **installations** in 2023, with **276,288 units** deployed.

Beyond technological overlap with the EV sector, China's advancements are bolstered by its strong **manufacturing capabilities** and extensive **supply chain infrastructure**, which facilitate large-scale production. China dominates humanoid robot component production, with **63% of key global actuator and rare earth processing companies** based in the country. These companies play a critical role in producing **high-precision sensors, control systems, motor parts, battery solutions, and semiconductor technology**. This supply chain advantage enables Chinese manufacturers to scale production at lower costs than international competitors, enhancing future commercialization prospects.

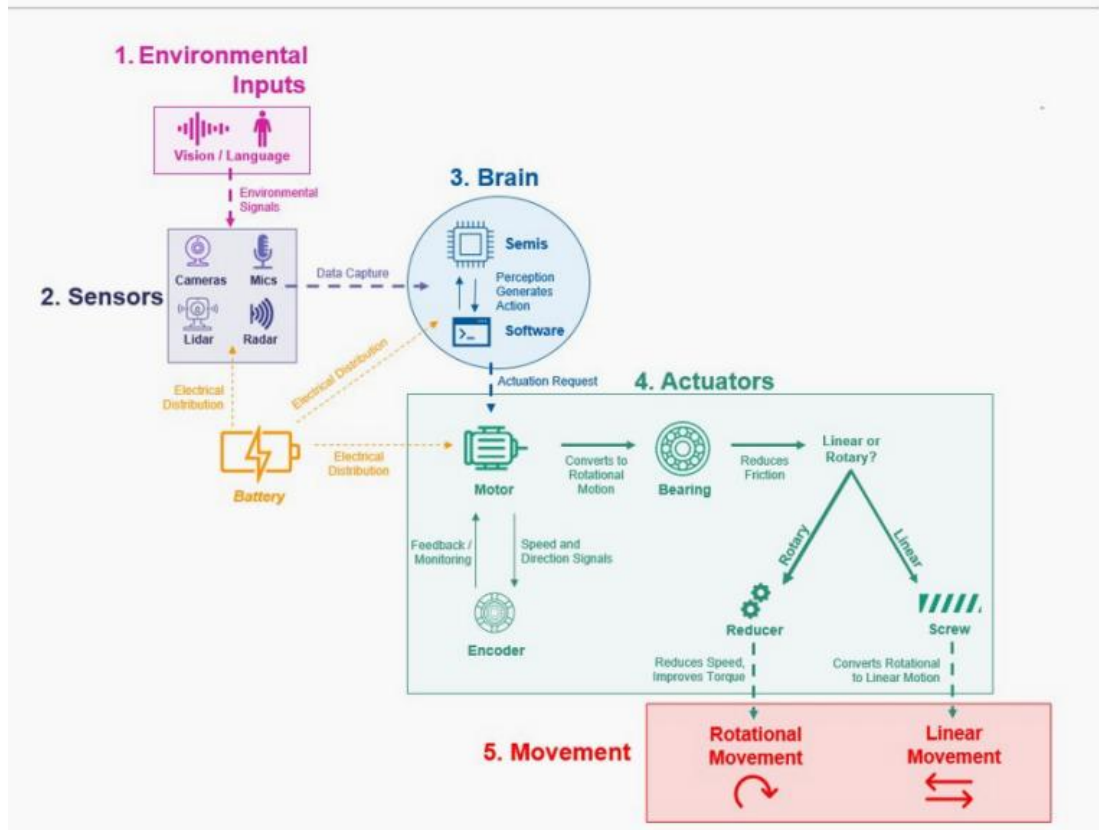
The **Chinese government** actively supports automation through **initiatives** like the **Robotics+ action plan**, which aims to double manufacturing robot density by 2025 compared to 2020 levels. **Provincial governments** also provide research and development subsidies covering **up to 30% of project costs** to foster innovation in automation technologies.

As of June 2024, **Shenzhen New Strategy Media's Industrial Research Institute** reported **over 160 humanoid robot manufacturers** worldwide, with **more than 60 in China, over 30 in the United States, and around 40 in Europe**.

Morgan Stanley projects that by 2050, China's humanoid robot market could grow to **6 trillion RMB**, with approximately **59 million robots** in operation. In comparison, the US humanoid market is projected to generate around **1 trillion dollars** by 2050, with rapid acceleration in revenue growth expected between the 2040s and 2050s.

1.4 Humanoid Robot Components and Core Technologies

Flow of Vision/Language to Humanoid Actuation



Source: Morgan Stanley Research

A humanoid robot consists of two major components: the **brain** and the **body**. The **brain** comprises **semiconductors and software**, which includes **foundational GenAI models** for autonomous functions as well as **simulation models** or digital twins for training.

The **body** integrates various **sensors**, such as **cameras, LiDAR, force, torque, and magnetic sensors**, along with **actuators** composed of **motors, encoders, bearings, screws, and reducers**. It also features a network of **wires and connectors**, powered by a centrally mounted lithium-ion battery, typically located in the chest. To maintain a lightweight structure, the **exterior** is usually made of aluminum alloys and plastics.

1.5 Challenges and Constraints

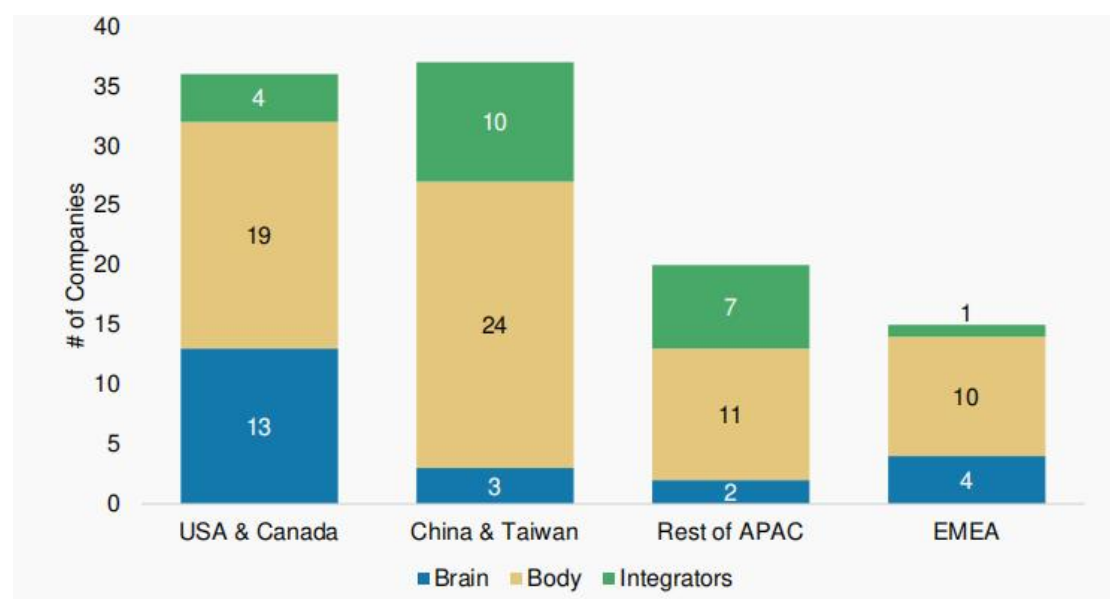
Despite China's strengths in humanoid robotics in areas such as batteries, sensors, and assembly, significant **challenges** remain in **AI and semiconductor development**, where global leaders like Nvidia, TSMC, Palantir, and Qualcomm continue to

dominate. China faces obstacles due to its reliance on foreign semiconductor manufacturing technologies, restrictions on advanced chip exports, and the complexity of AI model training, which requires cutting-edge hardware and vast datasets. In addition, China lags in foundational AI model development, high-performance computing infrastructure, and proprietary chip innovation.

Of the **22** major companies developing the “**brain**” of humanoid robots, referring to AI-driven cognitive and decision-making systems, only **3** are Chinese. In contrast, the US holds a clear advantage, driven by its strong ecosystem of AI talent, research institutions, and a series of government-backed projects.

To address this gap, China is increasing domestic semiconductor production, investing in AI startups, and fostering AI-driven applications. However, **overcoming structural dependencies** on Western firms in semiconductor design and high-performance computing remains a long-term challenge.

Humanoid 100 Brain/Body/Integrator Composition by Region



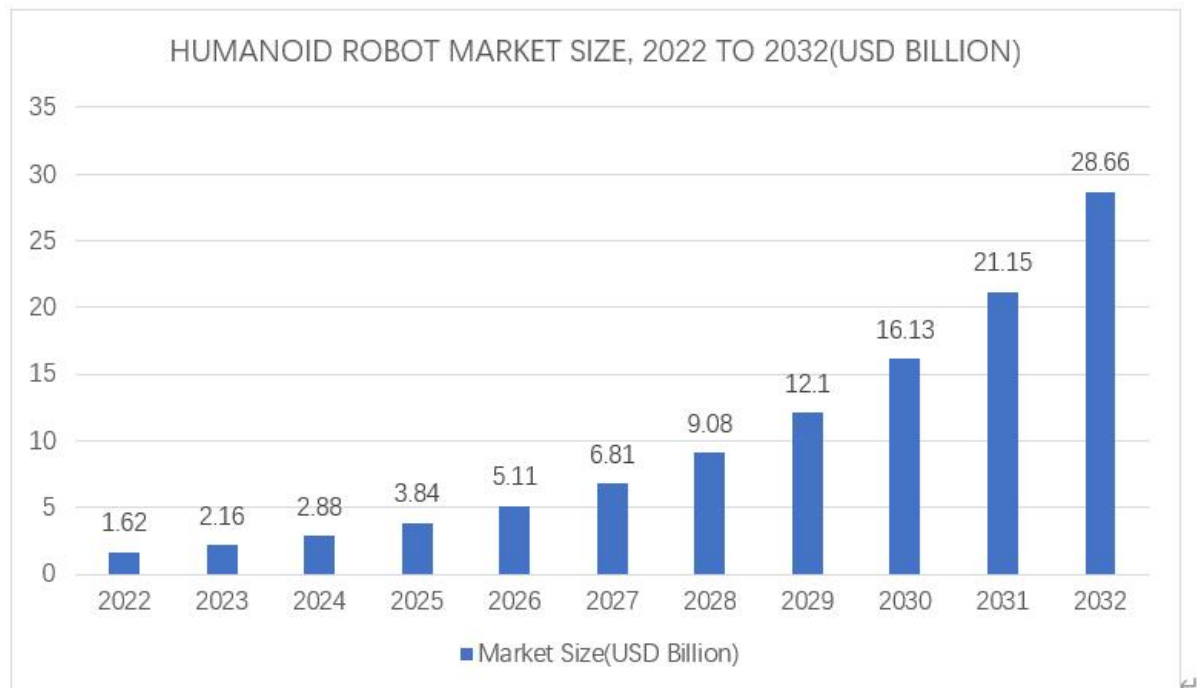
Source: Morgan Stanley Research

2. Market Analysis

2.1 Market Overview and Growth Trends

The humanoid robot market is experiencing rapid expansion, driven by advancements in AI algorithms, improved product readiness, and increasing applications across

industries. At CES 2025, several companies, including Unitree, Apptronix, and Realbotix, showcased their latest humanoid models capable of walking, jumping, and manipulating objects with dexterous hands. Market projections indicate an exponential increase in market size, rising from **\$1.62 billion in 2022** to an estimated **\$28.66 billion by 2032**. This growth reflects an accelerating adoption curve, particularly from 2027 onward, as technology matures and commercial applications expand.



Source: www.precedenceresearch.com

2.2 Geographical Distribution

The humanoid robotics market has a strong global presence, with key players emerging across different regions:

- **China:** Major manufacturers such as **UBTech, Unitree, Xiaomi, and AgiBot** are developing humanoid robots with **advanced vision systems and AI-powered interactions**.
- **United States:** **Tesla (Optimus), Boston Dynamics (Atlas), and Figure (Figure 02)** are leading the charge in **industrial and general-purpose humanoid robots**.
- **Other Key Regions:** Companies from Taiwan, Japan, and Europe are actively participating in the supply chain, especially in **camera components, vision algorithms, and AI-driven navigation systems**.

2.3 Competition Landscape

The humanoid robot ecosystem consists of several segments, including hardware manufacturers, camera suppliers, AI developers, and sensor providers. As the industry continues to grow, the global humanoid robot market is projected to reach **76,000 shipments by 2027** and **1.38 million units by 2035**, representing a **TAM of \$38 billion by 2030**.

The market for vision sensors and AI-powered components is also expanding rapidly, with the global machine vision market reaching **\$10.75 billion in 2023** and expected to grow at a **CAGR of 8.7% to \$22.59 billion by 2032**. The 3D machine vision market is projected to grow even faster, reaching **\$8.44 billion by 2032** at a **CAGR of 10.1%**. Meanwhile, the embodied intelligent robot vision sensor market is set to grow at a **28.7% CAGR from 2025 to 2031**, reaching **\$7.48 billion** by the end of the period.

Key industry players include:

- **Humanoid Robot Manufacturers**
 - a)**China**: UBTech (Walker S1), Unitree (G1), Xiaomi (CyberOne)
 - b)**US**: Tesla (Optimus), Figure (Figure 02), Appten (Apollo), Boston Dynamics (Atlas)
- **Camera and Vision Sensor Suppliers**
 - a)**Largan (3008.TW)**: Expanding into machine vision with plastic lenses for robotic applications.
 - b)**Will Semi (603501.SS)**: Provides CIS sensors optimized for humanoid robot vision.
 - c)**Horizon Robotics (9660.HK)**: Launched RDK AI vision algorithms for robots, supporting edge AI computing.
 - d)**Sunny Optical (2382.HK)**: Offers comprehensive vision solutions including ToF cameras, RGB cameras, and structured light sensors.
- **AI and Motion Control Providers**
 - a)**Horizon Robotics**: AI-powered SLAM and object recognition algorithms for humanoid robots.
 - b)**iSoftstone (301236.SZ)**: Developed humanoid robot motion control and NLP platforms.
 - c)**Deepglint (688207.SS)**: Focuses on AI-powered object recognition and human-robot interaction.

Visual specification of major humanoid robots

Company	Unitree	UBTech	Xiaomi	AgIBot	Tesla	Boston Dynamics	Fourier	Apptronik	Figure
Country	China	China	China	China	US	US	US	US	US
Model	G1	Walker S1	CyberOne	A2	Optimus	Atlas	GR-1	Apollo	Figure 02
Cameras	x1 Depth camera module (Intel RealSense D435i)	x2 RGB cameras x4 RGBD cameras	x1 Space visual module (Mi Sense) x1 AI interactive camera	x2 RGBD cameras x1 fisheye camera	x3 cameras	ToF camera RGB camera	x6 RGB cameras	x2 cameras	x6 RGB cameras
LiDar	x1 LiDar (LIVOX-MID360)	-	-	x1 LiDar	-	-	-	-	-

Source: Company data, Goldman Sachs Global Investment Research

2.4 Industry Applications

Humanoid robots are being integrated into various industries due to their ability to **mimic human movement and perform complex tasks**. Key applications include:

- **Healthcare and Elderly Care:** Foxconn and NVIDIA's collaboration focuses on humanoid robots for patient assistance and elderly care solutions.
- **Manufacturing and Logistics:** Companies like Boston Dynamics and Apptronik are developing robots for warehouse automation and industrial assembly lines.
- **Retail and Customer Service:** Robots equipped with AI-powered speech recognition and NLP, like iFlytek's AIBot platform, are enhancing retail and hospitality services.
- **Security and Surveillance:** Companies such as Hikvision and Dahua are leveraging AI vision solutions for security robots with 3D sensing and SLAM-based navigation.

3. Supply Chain Analysis

The humanoid robotics industry spans a complex supply chain, from **foundational upstream** component suppliers to **midstream manufacturers** and **downstream integrators** assembling full humanoid robots.

3.1 Upstream: Core Materials and Semiconductor Supply

At the foundation, the industry relies on **raw materials** such as **rare earth elements**, critical for high-performance motors and magnets, supplied by companies like JL Mag and MP Materials. **Semiconductor fabrication** giants, including TSMC, Samsung, and Intel, produce the advanced chips that power AI and real-time

processing in humanoid robots. **Battery technology**, essential for mobility, is led by manufacturers like CATL and Samsung SDI, while **memory producers** such as Micron and SK Hynix support the industry's computing needs.

3.2 Midstream: Component Manufacturing and System Development

The midstream layer consists of companies specializing in **robotic hardware and software development**. **Actuator components**- including bearings (NSK, Timken), gearing systems (Harmonic Drive, Nabtesco), and motors (Nidec, Estun)- enable precise movement and dexterity. **Vision and compute semiconductors** from NVIDIA, Qualcomm, and Intel drive perception and AI-driven decision-making. **Sensor technology**, such as **LiDAR, force sensors, and encoders**, is supplied by firms like Sony, Teledyne, and Allegro Microsystems, enabling humanoids to navigate and interact with their environments. **Analog semiconductors** from Infineon and Texas Instruments regulate power distribution and motor control, ensuring smooth operation.

3.3 Downstream: System Integration and Full Robot Assembly

At the final stage, **integrators** build complete humanoid robots by assembling components from upstream and midstream suppliers. This category includes both **large, established robotics firms** and **specialized startups** developing next-generation humanoid platforms. Companies like Tesla (Optimus), Agility Robotics (Digit), and Xiaomi (CyberOne) are actively designing and deploying humanoid robots, while industrial giants like Siemens, Rockwell Automation, and Foxconn leverage their automation expertise to scale production.

With advancements in AI, semiconductor technology, and automation, humanoid robotics is rapidly evolving into a fully-fledged industry. As **foundational models** like **NVIDIA's Project Gr00t** improve, alongside breakthroughs in **battery efficiency** and **actuator precision**, humanoids are becoming increasingly autonomous, cost-effective, and scalable for real-world applications.

3.4 Emerging Market Opportunities in the Supply Chain

The **commercialization** of humanoid robotics is creating new opportunities in China's supply chain for robot **sensing**, **motion**, and **interaction** technologies. Suppliers in these sectors are now accessing a **distinct market** apart from traditional electronics.

The **sensing** segment includes components such as **cameras**, **lenses**, **vision algorithms**, and **localization systems**. Humanoid robots rely on advanced 3D vision systems to perceive their surroundings, integrating multiple cameras, depth sensors, and LiDAR. The **motion** segment encompasses **robotic arms**, while the **interaction** segment features **voice recognition** and **natural language processing (NLP)** technologies. **Platform solutions** related to these technologies are also benefiting from this expansion. Goldman Sachs has identified Chinese companies such as Horizon Robotics, Largan, Will Semi, and Hon Hai as recommended investment opportunities.

4. Industry Outlook

4.1 Tech Breakthroughs

Advancements in **visual perception**, **AI computing**, and **dexterous manipulation** are driving the next generation of humanoid robots. Key innovations include:

- **3D Vision Systems:**

- a) **Tesla Optimus** uses a simple three-camera system, while UBTech Walker S1 and Figure 02 feature six cameras for improved depth sensing.

- b) **Boston Dynamics Atlas** and **Unitree G1** utilize LiDAR and ToF sensors for accurate spatial mapping.

- **AI-Powered Decision Making:**

- a) **Horizon Robotics' RDK OS** provides a one-stop solution for AI-powered robot applications, reducing development costs.

- b) **Deepglint** is refining gesture recognition and real-time object tracking to enhance humanoid robot adaptability.

- **Dexterous Hands and Fine Motor Skills:**

- a) **Lingyi (002600.SZ)** is developing humanoid hands with improved grasping capabilities, expanding robots' functional range.

4.2 Commercialization Roadmap

The transition from **prototype to mass production** is accelerating, with **AI-driven cost reduction** and **supply chain expansion** playing crucial roles. The roadmap includes:

- **2025-2027:**

- a) Increase in **pilot deployments in logistics, healthcare, and retail**.
- b) Expansion of **AI-powered software ecosystems** to support adaptive learning in humanoid robots.
- c) **Horizon Robotics' AI-powered RDK Studio** is expected to reduce development time for commercial humanoid applications.

- **2028-2030:**

- a) Large-scale commercialization with **widespread adoption in industrial automation and public service sectors**.
- b) More affordable, energy-efficient robots enabled by **advancements in edge AI computing**.
- c) **Greater China's camera and lens suppliers** are expected to dominate **global vision module production for humanoid robots**.

4.3 Investment Hotspots

As the market matures, key investment opportunities are emerging in:

- **AI Vision and Perception:**

- a) **Horizon Robotics, Sunny Optical, Will Semi, and Deepglint** are poised to lead the AI vision sector, enabling humanoid robots to process their environment more efficiently.

- **Camera and Sensor Supply Chain:**

- a) Companies like **Largan and O-Film** are diversifying into machine vision and ToF camera modules, benefiting from increasing demand for **3D depth sensing**.

- **AI Chips and Robotics Platforms:**

- a) **Horizon Robotics' RDK X4 and RDK S100 chipsets** are positioned as low-cost, high-performance solutions for humanoid robots.
- b) **Foxconn's partnership with NVIDIA** enhances its ability to scale humanoid robot production for service industries.

- **End-Application Integration:**

- a) **iSoftstone's humanoid robot**, powered by its self-developed Tianxuan LLM, presents opportunities in education and interactive AI applications.
- b) **Lingyi's humanoid hands and robotic assembly components** will be vital for industrial and service robot deployment.

The humanoid robot market is on a strong growth trajectory, fueled by AI breakthroughs, advanced vision systems, and increasing real-world applications. While competition is intensifying, companies with strong AI integration, vision system expertise, and robust supply chain positioning are expected to capture significant market share. The Greater China camera and lens supply chain is well-positioned to capitalize on this trend, enabling the next wave of humanoid robotics commercialization.

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