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News & Highlights

Chinese Robotics Take a Big (Dance) Step Forward

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In a late January 2025 program broadcast to a television audience of more than a billion viewers, 16 Unitree (Hangzhou, China) H1 humanoid robots joined human performers in a synchronized Yangko dance at the Chinese Spring Festival Gala [1]. Each robot featured more than 40 degrees of freedom (DOF) in its limbs, real-time motion planning, and stable gait control using terrain-agnostic algorithms. As they danced, the robots mimicked the human dancers in skillfully manipulating handkerchiefs (Fig. 1), a classic element of Yangko dance, creating a dazzling visual effect with their precise mechanical arm movements. This seamless ability to blend technology with cultural expression set the performance apart from dancing demonstrations staged with other humanoid robots manufactured by companies like Boston Dynamics (Waltham, MA, USA). Two months later, a Beijing half-marathon pitted humans against similar humanoid robots [2]. Chinese robots are also taking on other sports, including soccer and kickboxing [3,4].

These displays of athleticism do more than just entertain. They also offer compelling evidence of growing Chinese prowess in yet another heavily contested area of advanced engineering. Boosted by state-led industrial policies, advanced manufacturing capabilities, and a maturing artificial intelligence (AI) ecosystem, China's humanoid robots now appear poised, perhaps ahead of the competition, to take a much-anticipated big step from the pages of science fiction into the real world.

"The Chinese government has a resolute commitment to certain technologies, including humanoid robots," said Rob Atkinson, president of the Information Technology and Innovation Foundation, a Washington, DC-based think tank focused on scientific and technology policy. "They think they can leapfrog the rest of the world and become the Intel or Microsoft of humanoid robotics."

Chinese industries are working together to assess the practical usefulness of humanoid robots, said Jiayi Wang, a research scientist at the Beijing Institute for General Artificial Intelligence whose work, including graduate studies in Europe, has focused on legged robots. Instead of "building a superstar humanoid robot without figuring out how to scale it," Wang said the Chinese robotics strategy fosters "an iterative process that starts with seemingly simple tasks, like dancing, boxing, or soccer, that give engineers experience in building systems that work in the real world and enable continuous improvement through real-world feedback."

Why humanoid robots? Unlike single-task robots or robotic arms, humanoids can work in unmodified human environments using the same tools, spaces, and safety constraints [5]. That flexibility to perform a variety of tasks needing high dexterity and spatial reasoning is a critical prerequisite for delivering a broad range of potential applications, including in—perhaps most importantly—manufacturing, but also in customer and retail service, healthcare and elder care, education and training, hospitality and entertainment, emergency and hazardous environment support, and research [6]. But while this flexibility may expand possibilities, it does come at a cost; replicating human motions requires far more joints and actuators and onboard processing power than do single-task robots or robotic arms [5].

The drivers of China's interest in humanoid robots are clear: an aging population, rising labor costs, and falling prices for increasingly innovative robotics components [7,8]. The country's progress in robotics has potentially profound implications, not only for domestic and global manufacturing and meeting labor demands, but also for international technology dominance where US firms like NVIDIA (Santa Clara, CA, USA) and Tesla (Austin, TX, USA) are leading innovators in developing software to control robots as well as generating simulation data to train their control systems. Analysts project the global market for humanoid robots to reach 66

Fig. 1. Sixteen Unitree H1 robots took the stage with human dancers at the Chinese Spring Festival to perform a traditional Yangko dance for a televised event in January 2025. The dexterity with which the robots moved on stage, especially their manipulation of handkerchiefs, showed off H1's 40 DOF, real-time motion planning, and gait control. Credit: CCTV (public domain).

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billion USD by 2032 [9], with nearly 650 million humanoid robots deployed by 2050, increasing the market to an estimated 5 trillion to 7 trillion USD [10,11].

To push ahead of global competition, China's Ministry of Industry and Information Technology has mapped out ambitious plans to mass-produce humanoid robots by the end of 2025 and develop self-learning machines by 2027, all backed by 214 billion USD in public investment [12,13]. Chinese national-level policies such as the "Robot+" Application Action Plan and the Catalogue of Encouraged Industries for Foreign Investment have also invited foreign investment, giving international firms the opportunity to tap into the likely largest domestic market for robotics in the world [14]. "The advancement of robotics in China has been propelled by strong market demand and sustained investment, with key successes stemming from talent cultivation, funding initiatives, and the growth of specialized robotics firms," said Chenkun Qi, an associate professor of mechanical engineering specializing in robotics at Shanghai Jiao Tong University (Shanghai, China).

Innovation is also being driven by city-specific business clusters such as the Beijing Economic-Technological Development Area [15]. In 2024, Beijing mandated that carmakers test humanoids for use in assembly plants [16]. "The Chinese are very focused on not just the production, but how adoption complements production and creates a positive feedback loop of more deployment, more learning, and more economies of scale," Atkinson said.

The governmental support has quickly borne fruit. More than 60 of the world's 160 humanoid robot manufacturers are currently based in China [17]. Qi identified several Chinese companies, including Unitree, DEEP Robotics (Hangzhou), Zhiyuan Robot (Shanghai), LimX Dynamics (Shenzhen), and MagicLab (Wuxi), as industry leaders along with a handful of firms in Europe and the United States, including ANYbotics (Zurich, Switzerland), Boston Dynamics, Figure (San Jose, CA, USA), and Tesla.

China today leads the world with more industrial robots (470) per 10 000 workers than Germany, Japan, or the United States, and human–robot integration surging not just in high-end electric vehicle (EV) factories but also in small workshops producing less complex products like BBQ ovens [16]. China only entered the top 10 in robot per human worker density in 2019, with this metric doubling in just the past four years.

China also controls approximately 63% of the global humanoid robot component supply chain [18]. Actuators, harmonic drives, rare-earth magnets, and high-efficiency gearboxes are largely produced domestically. This vertical integration is crucial for scaling production, with price comparisons underscoring the advantage this provides: Unitree's H1 costs 90 000 USD while Boston Dynamics' comparable Atlas costs more than 200 000 USD [17].

In parallel with the hardware advances, the Beijing Humanoid Robot Innovation Center (Beijing, China) and the Chengdu Humanoid Robot Innovation Center Co., Ltd. (Chengdu, China) are developing AI "brain" systems that use multimodal perception and inference models to create machines with advanced thinking, understanding, and reasoning capabilities, unlike conventional robots that operate according to pre-programmed instructions [19]. Advances are also emerging from Chinese EV companies, whose technical skills and existing supply chains make them well-suited to pivot toward the manufacture of humanoid robots [20]. For example, XPENG's (Guangzhou, China) humanoid robot, Iron leverages the company's autonomous vehicle technology for navigation and manipulation; its 60-plus joints allow for 200-plus DOF, and its proprietary Turing AI chip give it a processing speed of 3000 trillions of operations per second (TOPS) [21]. Guangzhou Automobile Group Co., Ltd.'s (Guangzhou, China) GoMate robot, used for wire harnessing tasks, leverages multimodal AI perception for autonomous movement, voice recognition, and end-effector tracking while EV-grade batteries extend its operation time to more than 6 h [22].

Unitree's H1 and G1 robots have moved beyond fanciful demonstrations to functional deployments in Chinese EV factories and logistics and fulfillment centers [17]. The G1 (Fig. 2) is priced at 13 600 USD, making it one of the world's most affordable humanoid robots; it stands 127 cm-tall and features tendon-driven hands for delicate tasks and sensors that help it navigate complex environments [23]. Amazon (Seattle, WA, USA) is piloting the G1 for delivery of packages to customers' doorsteps [24]. In July 2025, Unitree released the R1, which it plans to sell for 5900 USD [25]. The 121 cm-tall R1 is aimed at early-stage research groups and software engineers who want to build on the H1 and G1 software stack.

In another example of functional robot deployment, the Chengdu Humanoid Robot Innovation Center Co., Ltd. unveiled seven humanoid robots intended to perform service and entertainment roles at the World Games 2025 in Chengdu in January 2025 [19]. The models include the fully humanoid bipedal Honghu and the Konka-1, a lightweight, 25 kg robot with a 5.5 kg payload and an eight-hour runtime that is "optimized for daily human interaction and complex semantic task execution" [19].

Robots built and programmed specifically for defined tasks may perform with better precision, but the functionality of these Chinese robots is good enough, said Wang. "Having spent time in Europe, I have seen very accurate robot control," he said. "China has not yet reached that level, but for most of the tasks you would want, moderate accuracy is enough, and China is very good at manufacturing all kinds of components, iterating on their designs, and bringing them to market."

In contrast to China's hardware adeptness, capital investment, and iteration strategy, the US approach to humanoid robotics has focused on advantages in software and a great capacity for generating massive amounts of synthetic data for algorithm training. Representative of US expertise in software control is NVIDIA's Isaac GR00T N1 humanoid robot (Fig. 3), an open foundation model

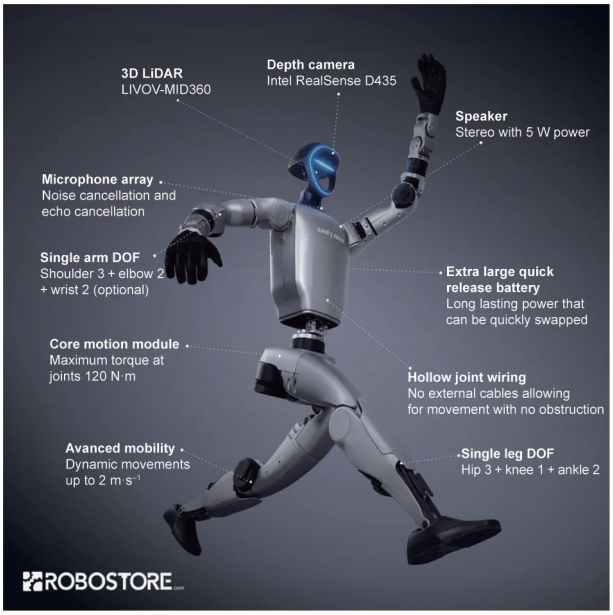

Fig. 2. Priced at 13 600 USD, the Unitree's G1 is one of the most affordable humanoid robots on the market. Amazon is currently testing whether the unit's ability to navigate complex environments and handle objects with care will make it effective at delivering packages to customers' doorsteps. Credit: Unitree Robostore (public domain).

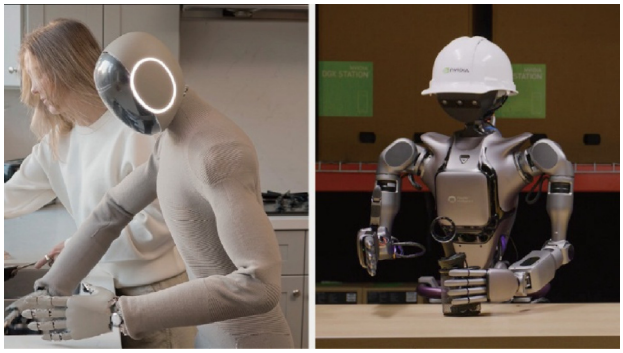

Fig. 3. NVIDIA developed its GR00T N1 humanoid robot to generalize across a variety of tasks, including grasping, sorting, and even domestic cleaning. Its dual-system control architecture features a fast-thinking, reflexive component and a slow-thinking methodical decision-making component. Credit: NVIDIA (public domain).

developed to generalize across a variety of tasks—grasping, sorting, bimanual manipulation, and even domestic cleaning [26]. Built with dual architecture inspired by human cognition, the robot's System 1 manages fast reflexes using imitation learning from human demonstrations while its System 2 uses a vision-language model for high-level reasoning and multistep planning [26].

One of NVIDIA's key breakthroughs is the Isaac GR00T Blueprint, a system that tracks human demonstrations of motion and then creates synthetic trajectories that GR00T can deploy. The system used 6.5 h of human demonstrations to extrapolate a synthetic dataset of 780 000 motion training trajectories, which improved motion accuracy by 40% compared to training on real human data alone [26].

In collaboration with Google DeepMind (London, UK) and Disney Research (Los Angeles, CA, USA), NVIDIA has also developed Newton, a software component called a physics engine that simulates the physical behavior of objects in a virtual environment [26]. The company says that Newton sets itself apart from other physics engines with "seamless AI integration, precise high-speed collision avoidance, and real-time adaptability" [27]. Early adopters of Newton include 1X (Palo Alto, CA, USA), Agility Robotics (Salem, OR, USA), Boston Dynamics, Mentee Robotics (Herzliya, Israel), and Neura Robotics (Metzingen, Germany) [26].

EV maker Tesla's Optimus humanoid robot, first unveiled in 2022, has matured from concept to operational prototype. With a goal of deploying 5000 units in its own factories by the end of 2025 to automate tasks like materials handling, component inspection, and eventually, assembly, Tesla is focusing on low-cost actuator design, minimizing the DOF needed for specific tasks, and transferring AI technology from its self-driving cars to Optimus [27,28]. Unlike NVIDIA's foundation model approach, Tesla's AI is purpose-trained for in-factory tasks, limiting generalizability but enhancing speed and energy efficiency. However, recent demonstrations featuring Optimus robots performing object manipulation and navigation were accompanied by accusations that the machines were controlled remotely by humans [29]. In another setback, the head of the Optimus program, Milan Kovac, has left the company and production has been delayed [30].

Regardless of who innovates the best hardware and software, most experts agree that the ultimate leader of the humanoid robot market will likely depend on who best integrates the two [26]. Mark Yim, professor of mechanical engineering and the director of the General Robotics, Automation, Sensing & Perception (GRASP) Laboratory at the University of Pennsylvania (Philadelphia, PA, USA), likened the situation to when people were trying to create a flying machine more than 100 years ago. At first, he said, the focus was on building a bird-like machine with flapping wings, a design approach that turned out to be disastrous. Eventually, people shifted to a fixed-wing design and the field took off. "Something similar is likely to happen in robotics, maybe within the next decade. And when it does, the industry could explode," Yim said. "The most straightforward answer about what that might be is machine learning—it is everywhere right now, and it will certainly be a part of whatever we do with robotics going forward."

Qi said successfully integrating AI with mature hardware platforms will be essential for achieving the broad autonomous functionality promised for humanoid robots. When this happens, "Robots will undoubtedly play an increasingly significant role in human production and daily life across various industries and fields."

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