Humanoid Robots and Tesla Optimus

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Summary

Using the Causality Link system to analyze the potential of the humanoid robot market for Tesla, I was surprised by two facts: first, the vibrancy of this market worldwide, and second what could be viewed as US "tunnel vision" on Optimus by Tesla. The worldwide effort to produce useful humanoid robots is incredible, with China again in a race for supremacy. Encouraged by their government in 2023, most of the large Chinese EV manufacturers have a humanoid robot program, and many of them are already testing these in their plants. In our corpus, the number of articles mentioning humanoid robots has doubled from 2023 to 2024, while Elon Musk has been able to capture most of the journalists' narrative on the topic by tripling (from 10% to 30%) the percentage of articles mentioning Optimus when they mentioned humanoid robots.

For a high-level US perspective, Congress released in October 2024 a good report on the comparative strategy and performance of the US and China for humanoid robots: https://www.uscc.gov/sites/default/files/2024-10/Humanoid_Robots.pdf

This paper attempts an estimate of the likelihood of Tesla dominating the humanoid robot market in the coming decade as asserted by Elon Musk and repeated by many financial analysts as a justification for Tesla's current valuation.

Humanoid robots and their potential market

Humanoid robots are robots that resemble a human body in shape and are designed to act and interact like humans. The first popular modern humanoid robot was ASIMO, introduced to the world by Honda in 2000. It showcased some of the advances of Honda in many scientific areas required to produce a bipedal robot which could offer minimum interactions with other humans. At that time, Honda was already envisioning a future where the aging population of Japan would shift its purchases from cars to robotic butlers at home.

The market for humanoid robots has expanded to manufacturing, warehousing, hospitality, security and healthcare. Goldman Sachs forecasts a humanoid robot market of $38B in 2035. Grand View Research sees a $6B market in 2035. Elon Musk is envisioning a market of over $10T per year (https://www.youtube.com/watch?v=3vsPKMWJ0lk) of which he expects to get about 10%, for a one trillion dollars of revenue for Tesla, at some unknown point in the future. This justified in his mind an additional valuation of $25T for Tesla: https://finance.yahoo.com/news/elon-musk-optimus-bot-stole-212807015.html . Such lofty future statements attract a lot of media and investor attention. However, there is quite a difference between analysts' estimation of a $6-38B market in 10 years, and the $10T Musk's estimation in an unspecified number of decades. It is therefore worth estimating how the competition for Optimus could develop over these coming decades and degrade the 10% minimum market share for Tesla promised by Elon Musk.

Humanoid robot technologies

Humanoid robots' progress can be traced to the convergence of major advances in multiple technologies:

- Joints https://cctygroup.com/articulating-joints-in-robots/
- Muscles https://www.robotics247.com/article/elysium_robotics_develops_human_muscle_like_actuators which enable more precise and energy-efficient movements, with dielectric elastomer actuators showing great potential: https://www.nature.com/articles/s41467-024-48243-y
- Nervous systems, as represented by AI, machine learning and dedicated AI chips for balance, vision, interactions with their environment, including learning and collaboration with other robots.

It is worth noting that while AI for self-driving vehicles is complex, and not yet perfect, as the many analyses of Tesla's FSD demonstrate, there are only two main control variables in a car, namely its speed and direction, and cars drive mostly on the predictable surface of a road. On the other hand, the AI required to power multi-usage humanoid robots is way more complex, due both to the large number of "degrees of freedom" of humanoid shapes, and due to the variety of environments and tasks that these robots will face: man-made environments such as industrial environments, homes, hospitals, hotels, as well as the infinite variety of natural environments including sand, rocks, forests, bogs, etc...

It is therefore not surprising that vertically specialized humanoid robots have emerged first, and that so far, most Optimus demonstrations have been tele-operated.

Current Humanoid Robots

Many companies are already selling autonomous humanoid robots around the world, such as Norwegian 1X selling NEO, Israeli Mentee Robotics selling MenteeBot, Polish Clone Robotics accepting pre-orders for Clone Alpha, British Engineering Arts selling Ameca, among others.

According to the Association for Advancing Automation https://www.automate.org/robotics/blogs/humanoid-robots-top-companies the main US companies advertising deployed humanoid robots are Figure AI with Figure 01 and Figure 02, Boston Dynamics (owned by Hyundai) with Atlas, Agility Robotics with Digit, Apptronik with Apollo and Sanctuary AI with Phoenix. Moreover, NVIDIA is developing a platform and chips to build humanoid robots, which will certainly open the market to new entrants in that space.

With their demonstrated achievements, and their strong financial backing, these companies compete with Tesla's Optimus and will have made great progress when it becomes commercially available in 2026. It is still believable that Tesla will get a 10 to 20% market share of the market of these US competitors.

However, the picture changes dramatically when we lose our US focus and turn our attention to China. The number of actors is much larger, as demonstrated in the 2024 World Robot Conference held in Beijing: https://www.youtube.com/watch?v=giyl27gKvS4 with strong independent robot-focused companies such as UBTech Robotics already testing Walker S1 in Zeeker plants, Leju Robotics already testing Kuafu in NIO plants, Unitree Robotics currently selling G1 for $16,000, Fourier Robotics winning a DIA 2024 prize for GR-1 and more.

Then, most of the serious EV Chinese competitors of Tesla have an in-house humanoid robot effort such as Xiaomi with CyberOne, XPeng with Iron, while BYD Electronics is also testing Walker S1. The evaluation of these humanoid robots is underway in Chinese factories well ahead of the 2025 plans of Tesla for Optimus.

Finally, the Chinese government has encouraged partnerships where robotics companies leverage the AI developments of larger companies: UBTech uses Baidu AI, while Leju Robotics uses Huawei AI, or of powerful universities such as RobotEra, maker of the Star1 general-purpose robot, developing an open-source simulation environment Humanoid-Gym with Tsinghua University. This country-level strategy competes with the fully integrated strategy of Tesla and will apply many more engineers to this problem in China than Tesla can leverage.

Forecast

There is no doubt that the humanoid robot market will reach tens of billions of dollars in ten years. And there is no doubt that Elon Musk has contributed to putting the topic at the top of many governments and companies' agendas in the manufacturing and defense industries.

However, the development speed advantage that has benefited Tesla in its early years, and still benefits it against its Western competitors, does not apply in China, which incorporates innovations and improves on them faster than Tesla itself. This has been demonstrated against Tesla by BYD in electric vehicles, against Tesla by CATL in energy storage, against Alcatel by Huawei in telecommunications, against Apple by Xiaomi in phones, against Amazon by Alibaba in e-commerce and many more.

It is therefore doubtful that Tesla will be able to achieve and maintain during decades a significant market share in a domain where Chinese competitors are already entrenched, where they are applying larger amounts of collaborative engineering efforts and where they benefit from a much larger manufacturing market. It would take a successful national humanoid robot program in the US to counter the Chinese effort, and to give Tesla a chance to compete and win in this promising market in order to justify its current lofty valuation.