Rady Action Project

Intel's Path into Physical AI

June 4, 2025

intel.

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Meet our Rady Action Project team

Primary research hours: 20

Secondary research hours: 148

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A special thanks to Intel

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Agenda

1. Where we are
2. Visualize the stack
3. What is holding the industry back?
4. Where is the industry headed?
5. What could Intel do?

Primary Research

GLG Industry Experts:

1. Former **Tesla** Product Management Director
2. **Plus One Robotics** Principal Architect
3. Director of Automation and Operational Technology at **Kimberly-Clark Corporation**
4. Former Senior Vice President and General Manager - Warehouse Robotics at **Boston Dynamics, Inc.**
5. Senior Software Engineer at **Launchpad Build, Inc.**
6. Research Scientist and Tech Lead for Humanoids, Robotics, **Google DeepMind**

UCSD Professors and Professional Network:

- Executive Director at MassRobotics
- Philosophy PhD and researcher on ethics, responsibility, and governance of AI

Secondary Research

And more!

Our research is backed by industry experts

Our team conducted blind interviews with experts who worked professionally with physical AI, found through Gerson Lehrman Group (GLG)

Categories of experts

- **Uses AI-powered robotics in industry**
- **Builds robots**
- **Involved in software stack within robotics**

Envision the next industrial era

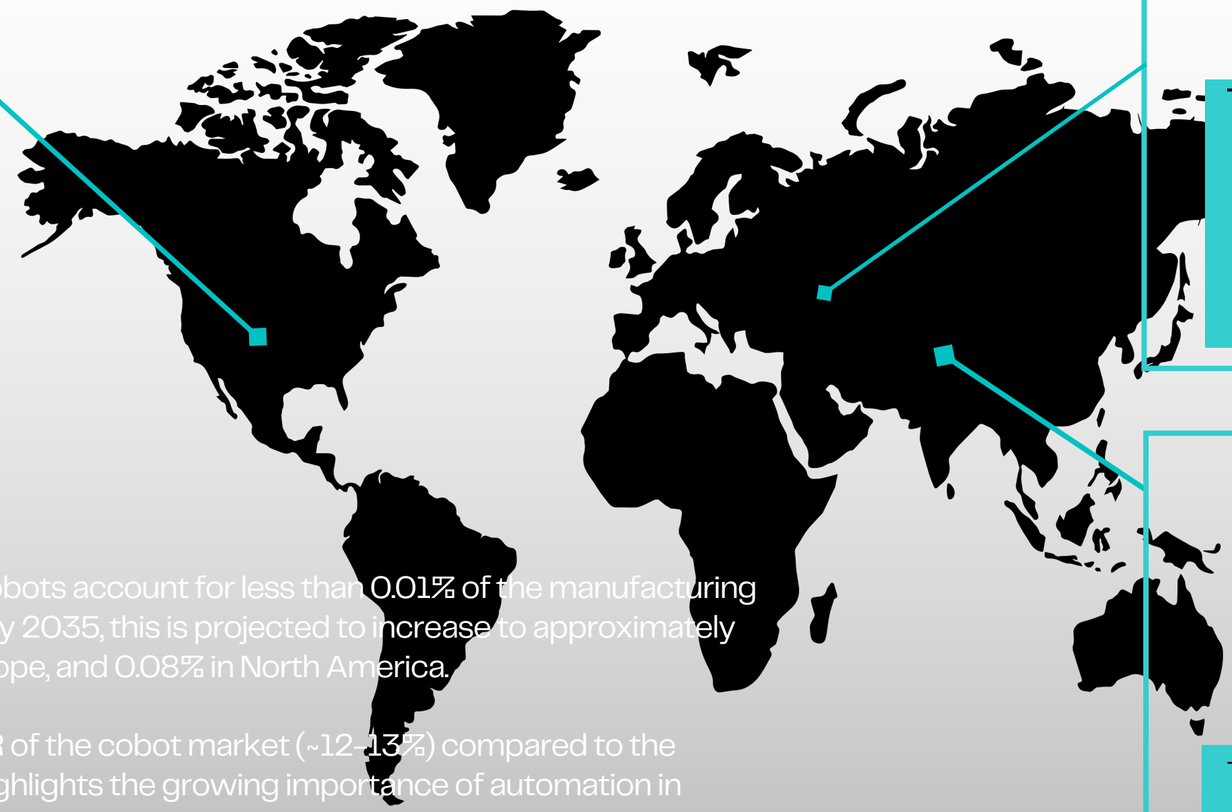
"If our era is the next industrial revolution, as many claim, AI is surely one of its driving forces" – Professor Fei-Fei Li (Stanford)

This time, the stakes are higher: redefine industrial manufacturing or fall behind

What should Intel do to lead the Physical AI future?

Source : The New York Times

The cobot market is emerging in manufacturing



Manufacturing Market Size:
$2.6T (2025)
Manufacturing CAGR:
1%

Cobot Market Size:
$357.8M
Cobot CAGR:
12%

Trends

- Tariffs hurt exports and increase costs
- Automation replaces labor (employment ↓ 0.5% CAGR)

North America

Manufacturing Market Size:
$3.2T (2025)
Manufacturing CAGR:
1%
Cobot Market Size:
$603.2M
Cobot CAGR:
13%

Trends

- High labor costs & regulations drive cobot growth
- Safety/integration regulations may hinder pace

Europe

Manufacturing Market Size:
$8T (2025)
Manufacturing CAGR:
2%
Cobot Market Size:
$1,020M
Cobot CAGR:
13%

Trends

- Rapid industrialization creates potential for cobot adoption; (China, Japan, South Korea)
- Political/economic instability affects supply chains.

Asia

- Penetration Rates: As of 2025, cobots account for less than 0.01% of the manufacturing market value across all regions. By 2035, this is projected to increase to approximately 0.05% in Asia-Pacific, 0.1% in Europe, and 0.08% in North America.
- Growth Potential: The high CAGR of the cobot market (~12–13%) compared to the manufacturing sector (~1–2%) highlights the growing importance of automation in manufacturing.

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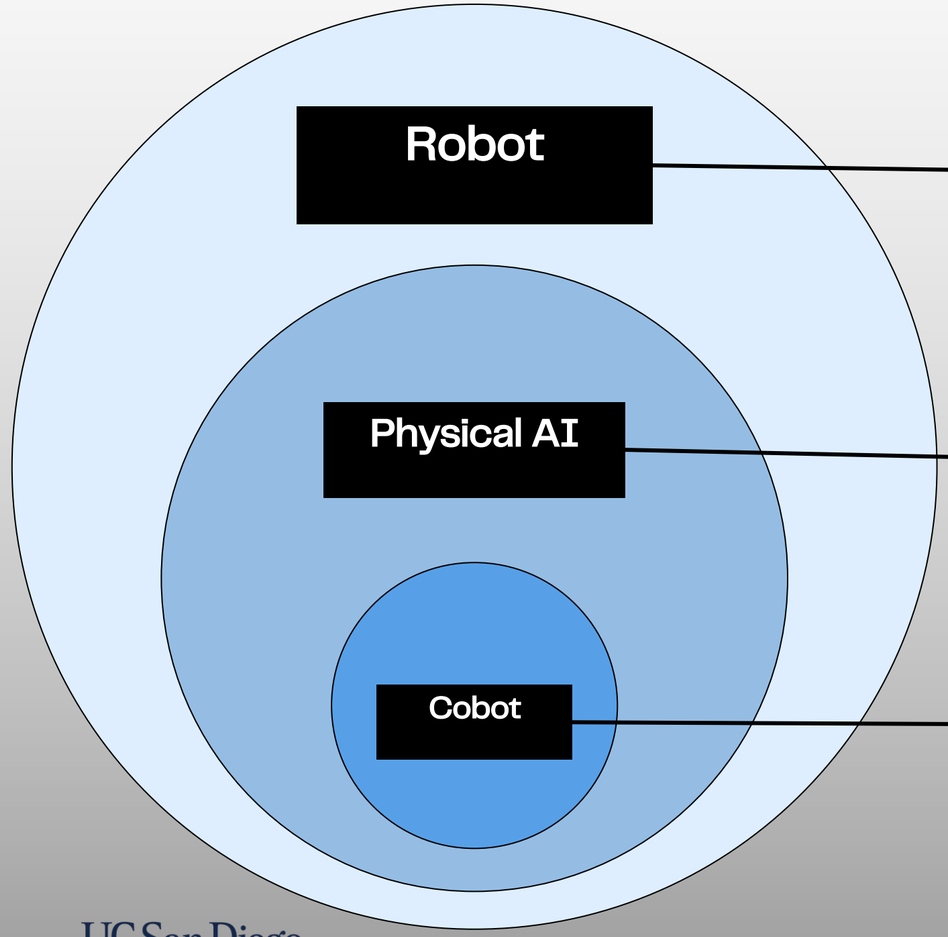
Sources: **BIS Research**, Statista NA, Statista EU, Statista Asia

Physical AI = convergence of robotics, AI, and autonomy



A machine that is programmed to carry out a series of actions automatically that involve direct interaction with the physical world.

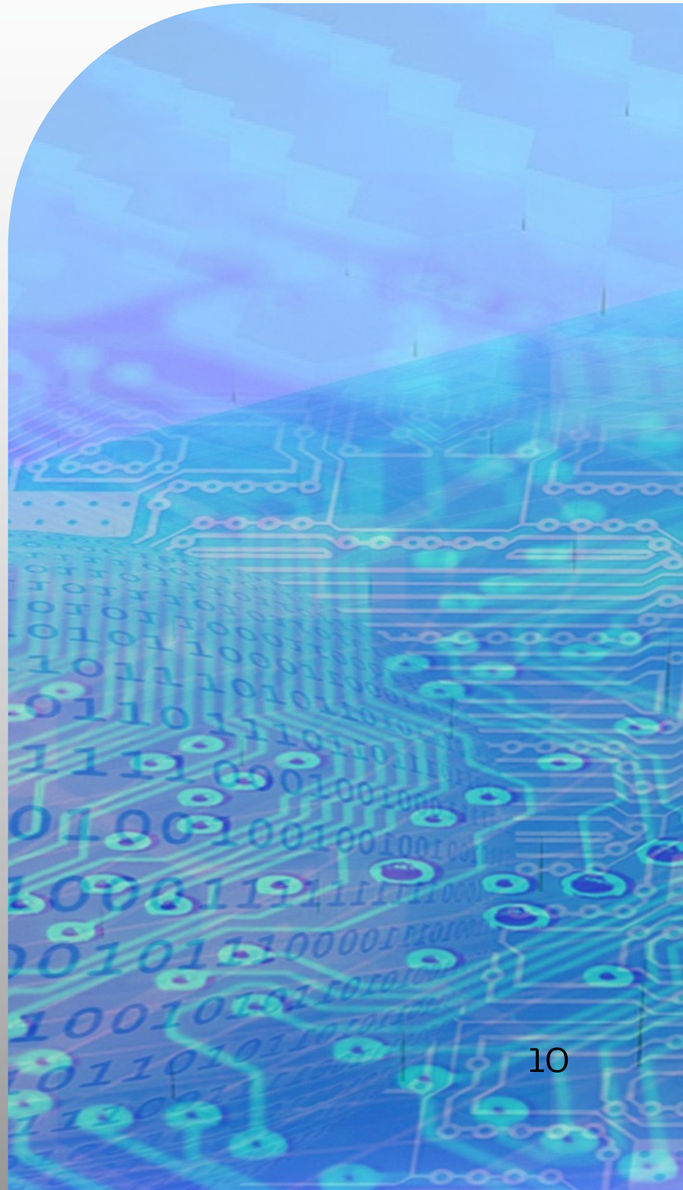
- Ex: arms on production lines, spray painting machines

An autonomous and agentic system that uses AI computation to directly interact with the physical world

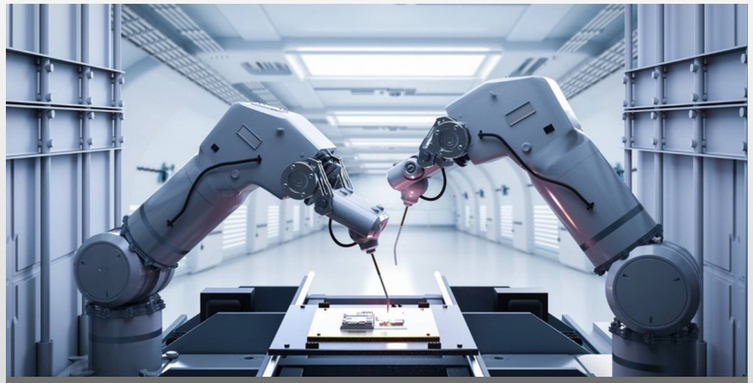
- e.g., by observing the world through sensors or by modifying the world through actuators.
- Actions being taken use agency
- A Robot that can make decisions agentically

A robot that utilizes AI to dynamically adapt to collaborating with humans in a working space

Where we are



Transforming the Manufacturing Industry: From 4.0 to 6.0



Industry 4.0

Work for us. (~2010 - ongoing) nvolves supplementing existing manufacturing operations with A

Industry 5.0

Work alongside us. (~2020-emerging) nvolves utilization of cobots working with humans to intuitively adapt to different scenarios and dynamically take more control of these processes

Industry 6.0

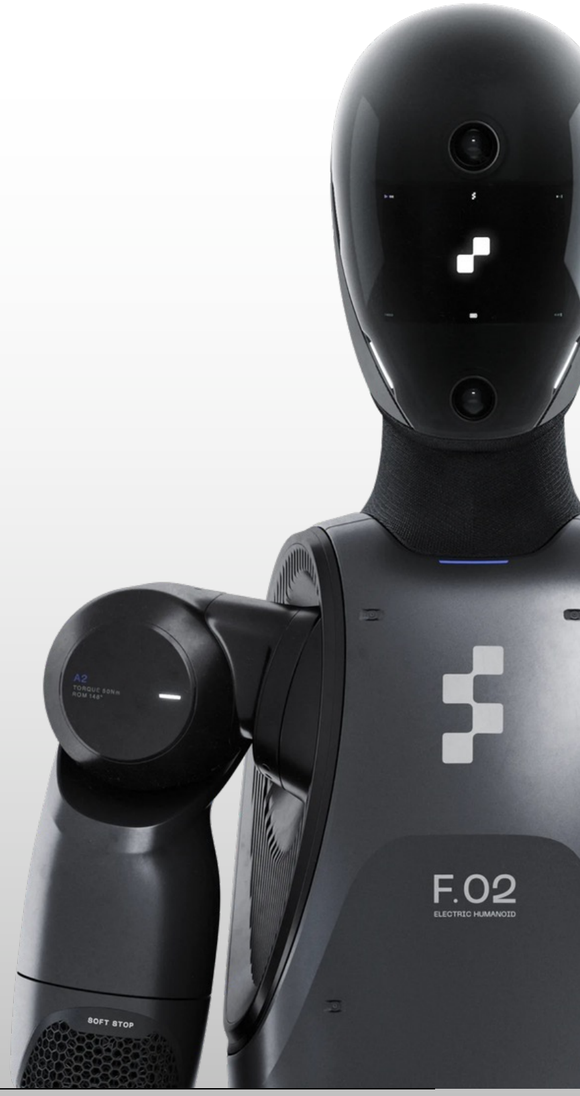
Work without us. (~2030 - conceptual) Aand robotics autonomously manage the entire product lifecycle without human involvement. A key concept is “lights-out manufacturing” in which automated factories can operate without human

BMW tested the Figure 02 humanoid robot at their Spartanburg manufacturing plant

Task: Inserting sheet metal parts into fixtures for chassis assembly

Goal: To test humanoid robots in an automotive manufacturing settings and to collect data to train these robots

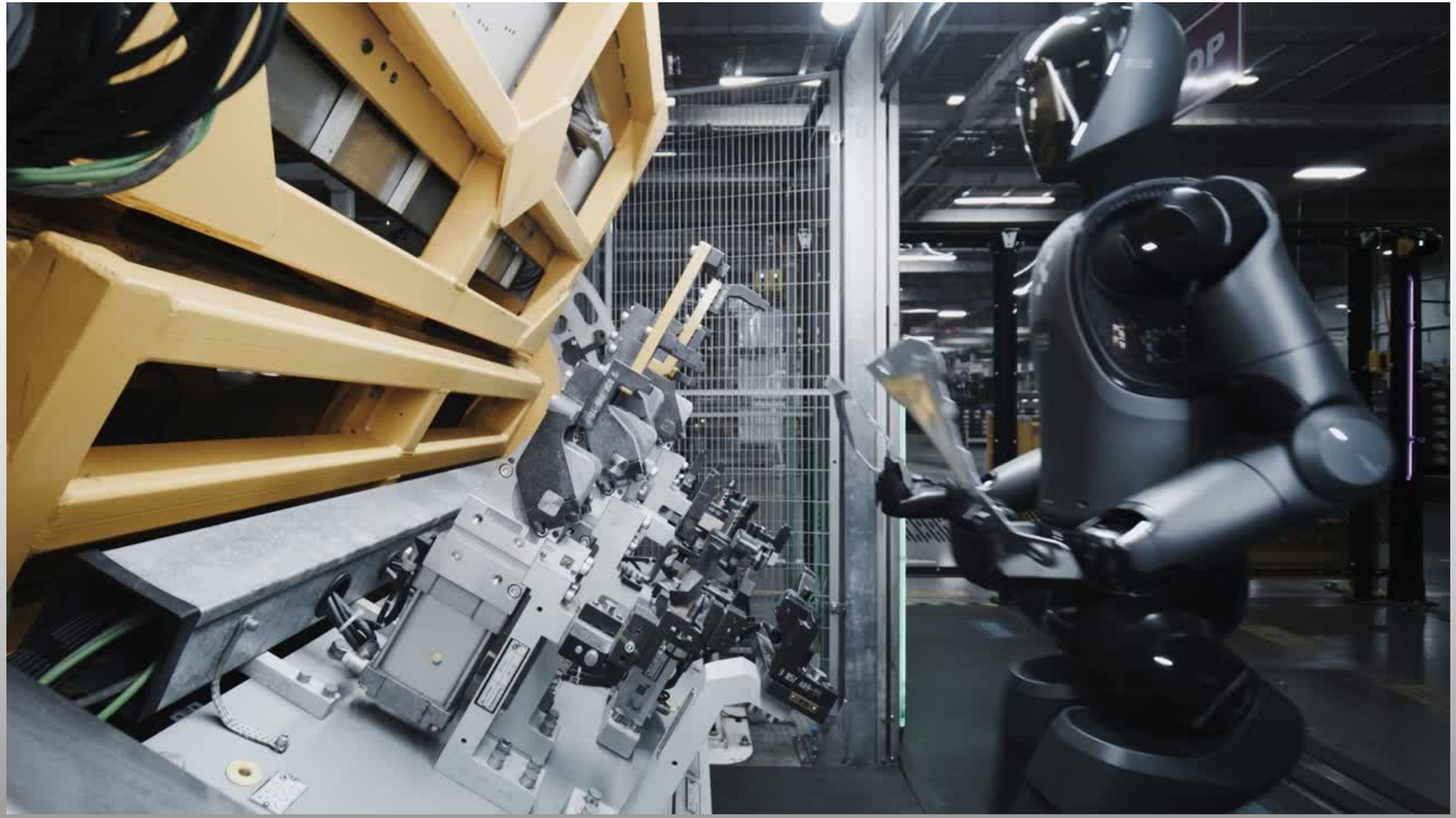
Is this practical?



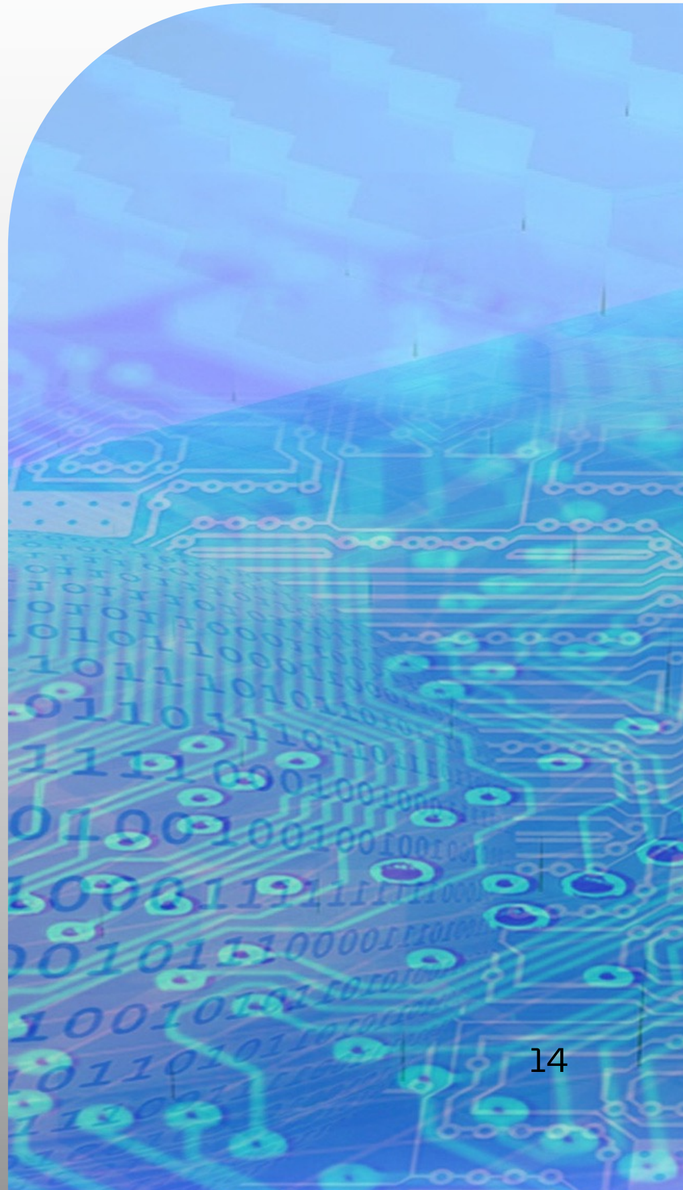
Physical AI in action

"If you had a single robot capable of doing all the things we as people can do, then you might have a solution to automate that part of the [automotive] plant" – Senior Vice President, Boston Robotics

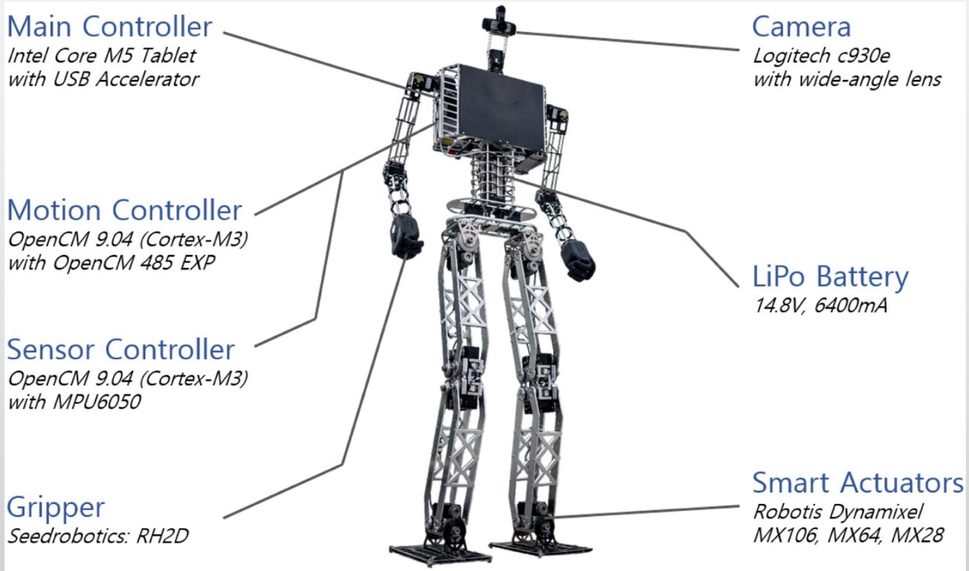
Source: BMW Group



Visualize the stack



The robot itself: The embodied brain & body



Processing Units
CPUs, GPUs, and NPUs collaborate to execute complex algorithms for perception, planning, and control, enabling fast, real-time robot decisions and adaptive behavior.

Sensors
High-resolution cameras, tactile arrays, and proximity sensors gather data to provide spatial awareness and obstacle detection for precise interactions.

Actuators
Servomotors and electro-mechanical actuators convert signals into smooth, dexterous movements to manipulate objects and navigate complex environments.

Power Systems
Long-lasting lithium-ion batteries with smart energy management deliver stable, high-density power for extended robot autonomy.

Soft Robotics
Elastic materials and pneumatic actuators create compliant structures that safely conform to human touch and fragile objects for sensitive manipulation.

The Software Ecosystem: Intelligence & Support Structure

Cloud Infrastructure

Centralized storage and over-the-air updates enable robust fleet control, real-time data aggregation, and resource efficiency.

Simulation & Digital Twins

Virtual environments replicate physical spaces to enable safe training and predictive maintenance.

AI Training Infrastructure

Powerful GPU clusters handle large datasets to build adaptable and intelligent robot models.

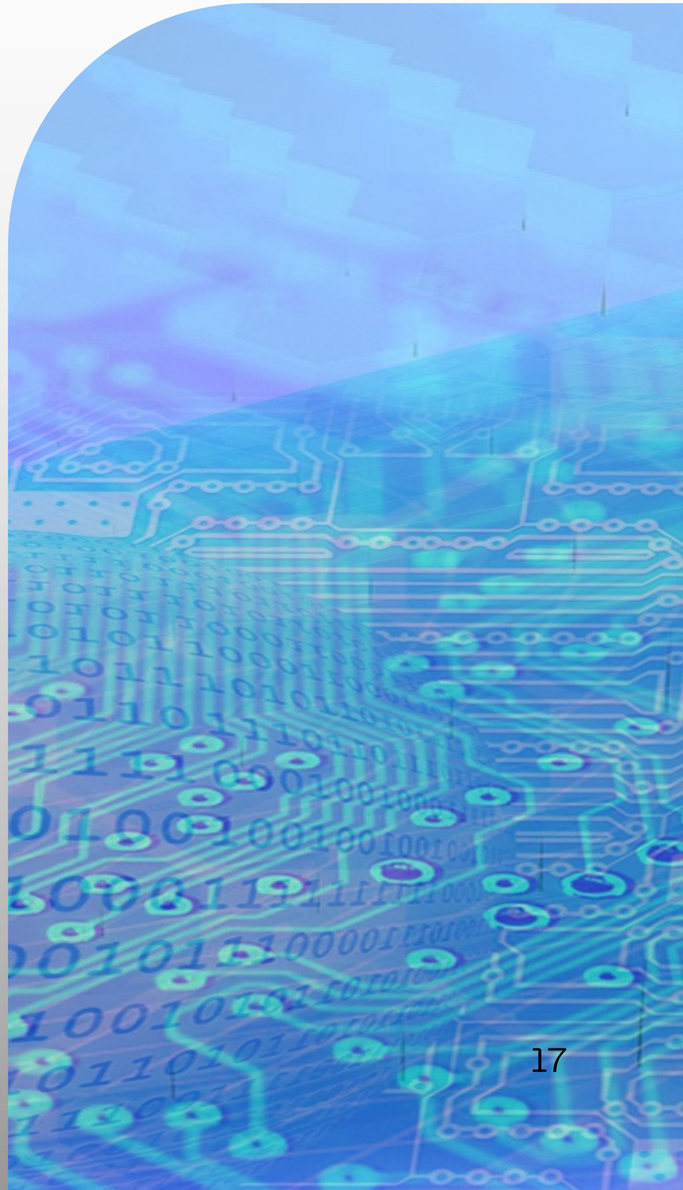
Development Frameworks

Platforms like ROS provide modular tools and libraries that speed development and foster innovation.

"Hardware is not differentiator anymore, now software is the big separator (whoever is going to win the race should be focused on the software)"

– Former Director of Product Management, Tesla

What is holding the industry back?



The physical AI era raises concerns

- Ethical concerns
  - Achievement gap: humans being discredited for joint work with AI; managing AI is a new challenge
  - Hidden labor: valuable work that isn't recognized, rewarded, or protected, such as low wage labor used to train LLMs
- AI continuing trend of changing job landscape due to automation: roles relating to robotics will continue to grow, and reskilling may be required
- 61% of people stated they were uncomfortable with Robots (Brookings Institution survey)

"Some people may not feasibly be able to retool. While it's easier for younger workers to adjust, someone that has been doing their job for 30 years is harder to retrain."

– UCSD Philosophy PhD[18]

Source : Brookings, Springer

Revealing emergent risks

- Rate of job displacement
  - Oxford prediction: 20 million manufacturing jobs to be displaced globally between 2019–2030
- Increased attack surface for cybersecurity threats
  - Maturity and proper design of security systems is imperative
- Safety standards and solutions for humanoid robots are still nascent

"500,000 jobs being displaced over the course of 10 years is much less taxing on society than 500,000 jobs being displaced over the course of 4 months."

–UCSD Philosophy PhD and AI ethics, responsibility, and governance researcher

Source : UCSD, ScienceDirect, Cambridge, Oxford Economics

Regulation is falling behind the advancements of robots

- Current regulatory frameworks are fragmented and outdated, struggling to address key legal debates such as liability, personhood, and robotic autonomy
- Regulation is needed to address responsibility gap for adverse events
  - Example proposal: base liability is on behavior that could have been reasonably foreseen, and negligence to prevent harm
  - Limited liability to corporations, similar framework to liability of an animal owner
  - Individual contracts need to have language addressing this for the time being

"A 150-pound robot falling on a manufacturing line is still very much a possibility. [Potential customers may require] a third-party safety certification, which could be very difficult to get because this is a new technology with no real safety standards that have been established and accepted. "

– Google DeepMind Expert

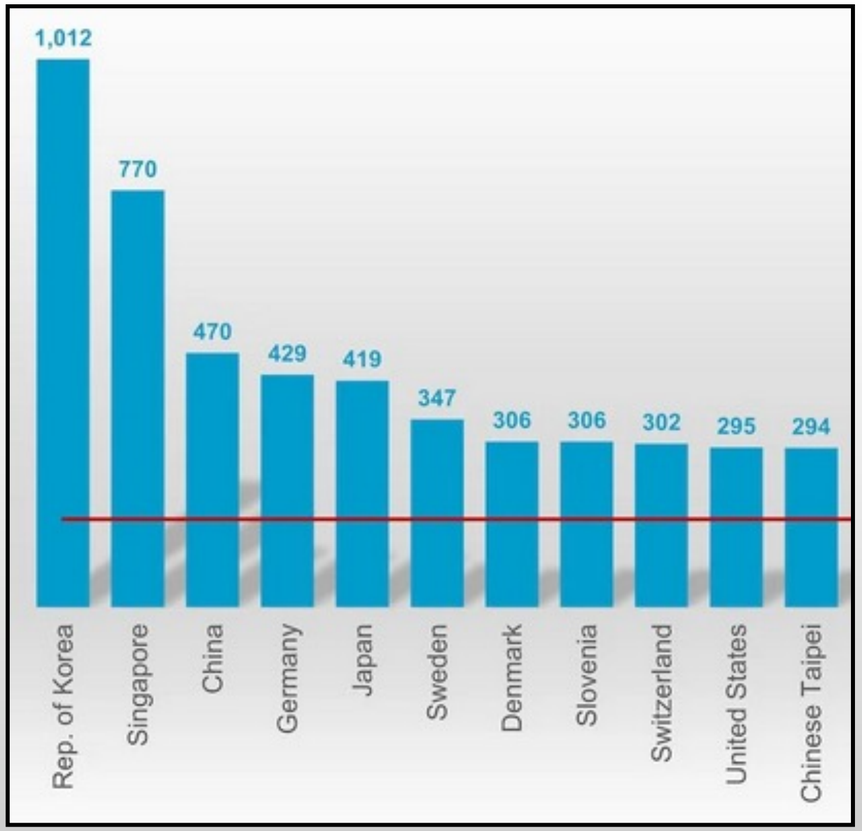
Source : Cambridge, Springer, Springer


Camera 01

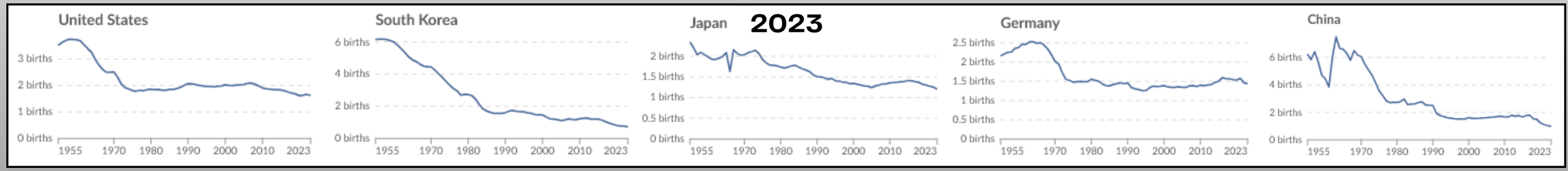
Accelerating global adoption through cost and demographic tailwinds

- Decreasing implementation costs
- Increasing demand due to falling birth rates + aging population
  - 1% decrease in population growth ~ 2% increase in robot density
- Improvement of foundation models will further reduce application-specific costs

Robots installed per 10,000 manufacturing employees, 2023



Fertility rates, 1955–2023



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Source: ScienceDirect, MDPI, Ourworldindata, IFR

Addressing region-specific adoption challenges

European Union

- Automotive sector falling behind China; potential reduced investment

Asia

- Low costs of labor in SEA countries results in lower ROI from investing heavily in automation

USA

- 98% of manufacturing operations are small to medium sized; lack of capital available for cutting-edge systems
- Current reliance on imported robots and critical components

Source: SCSP.ai, IFR

Strategic support across regions is laying the foundation for growth

European Union

- Policy support for Industry 4.0, such as Robotics Institute Germany
  - Strategic goals for RIG: Making robotics research competitive through benchmarking and competitions, sharing infrastructure and resources, promoting talent and offering education through major universities, simplifying the transfer of research outcomes for industry

Asia

- Many greenfield sites designed around AI focused automation

USA

- Record high venture investment in 2021–2022 in robotics startups; maturation will help with domestic supply

Source: Therobotreport, UN Trade & Development

AI models stimulate adoption

Tailwinds (Accelerating Adoption)

1. Increased reliance on simulations to ease adoption efforts of physical AI
    - Simulations reduce cost and risk of real-world testing, speeding up R&D and deployment cycles.
2. Foundation models as commercial plug-and-play solutions
    - Companies can now leverage pre-trained AI models—already trained on massive datasets (e.g., object manipulation, visual recognition)
    - These reduce the technical burden for companies, enabling faster integration of AI into workflows with less customization.
    - Covariant, Google DeepMind, and NVIDIA
3. Increased data collection efforts to fuel AI training
    - More data improves model performance and generalizability, making AI more useful across a wider range of industrial tasks.

High capex, data, and energy requirements are bottlenecks

Headwinds (Delaying Adoption)

1. High upfront costs and retrofitting are required, with some legacy systems unsupported
    - High end robotic cost $100k. (Plus maintenance, installation and training)
2. Absence of advanced industrial data
    - Many industries still lack structured, high-quality datasets, limiting the effectiveness and accuracy of AI applications.
3. Compute, energy, and safety concerns (Implied from the last point)
    - While progress is being made, high compute demands and energy consumption, as well as safety and reasoning limitations, still pose obstacles to full-scale deployment.

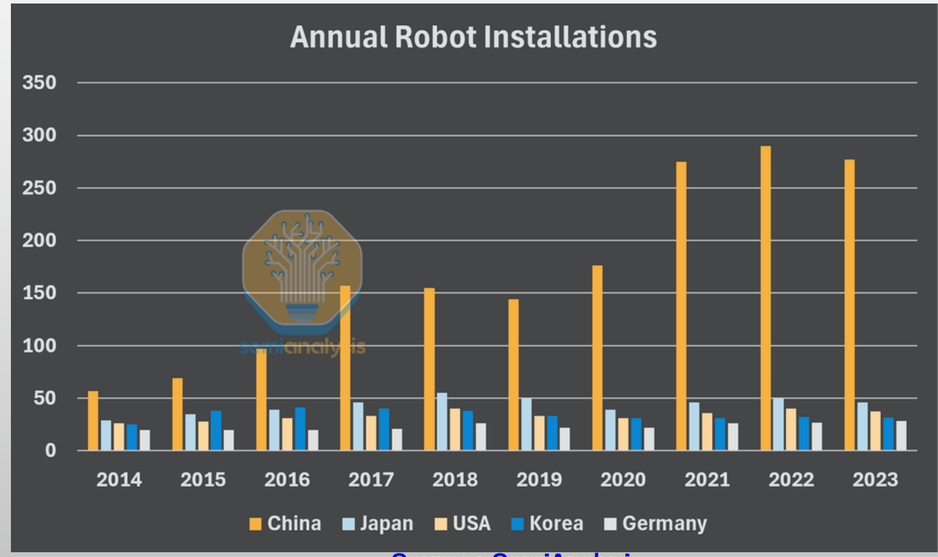
On Data Collection for AI:

"The first precursor to it happening would be that somebody would need to amass a data set of diverse robotic tasks in real environments. **That is a couple orders of magnitude larger than the largest data sets than any organization is currently working with."**

– Google DeepMind Expert

China has the lead in robotics

- Global competition to control AI hardware and robotics technologies
- **China's Robotics Lead**: 51% of global robot installations now come from China, driven by subsidies, industrial scale, and localization.
- **Speed & Scale Advantage**: China iterates faster and cheaper—G1 Unitree's $16K humanoid shows their ability to outpace global rivals.
- **Supply Chain Dominance**: China controls critical inputs—rare earths, motors, batteries, LiDAR—undermining Western independence.
- **Strategic Move for Intel:** As global tensions rise, Intel can lead by providing secure, local supply chains—especially for robotics in healthcare, defense, and infrastructure.

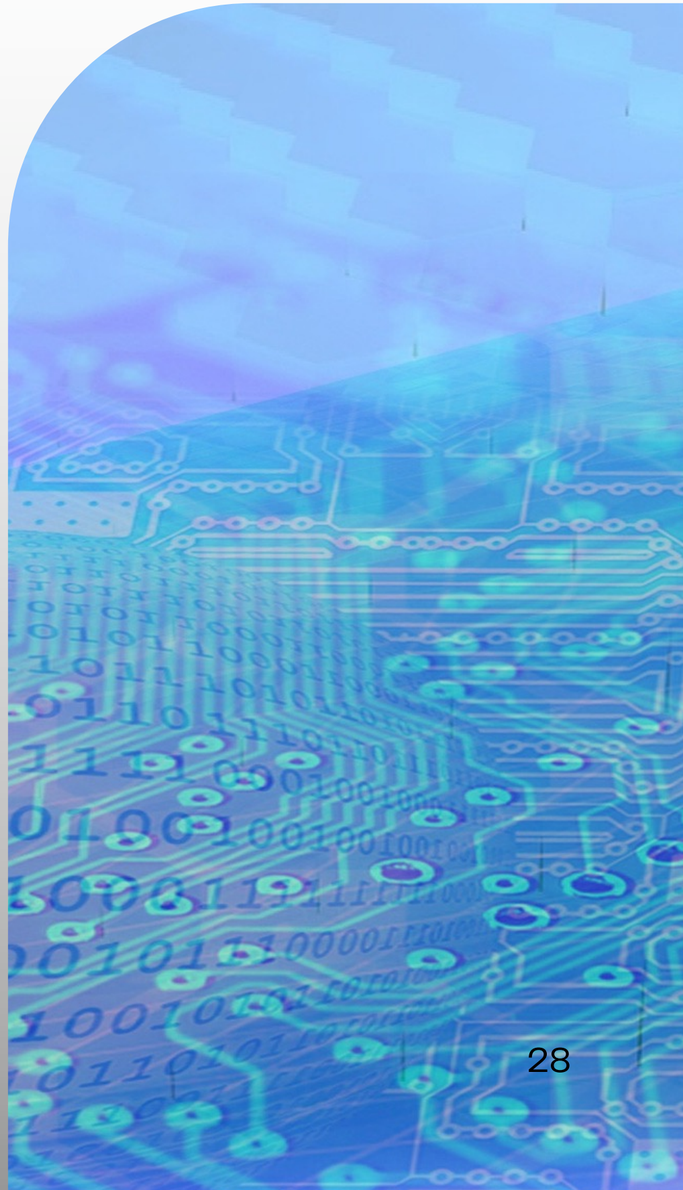


Source : SemiAnalysis

"Before the geopolitical storms, China was quietly taking over the robotics space. Now, tensions are slowing global expansion—but giving Western firms a rare breathing space to survive."

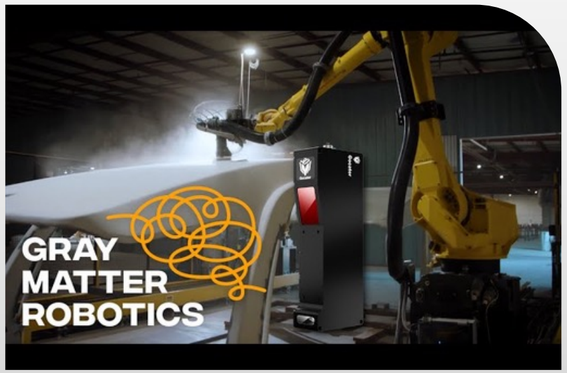
– ABB Expert

Where is the industry headed?



Startups paving the way for adoption

Real-World Innovations

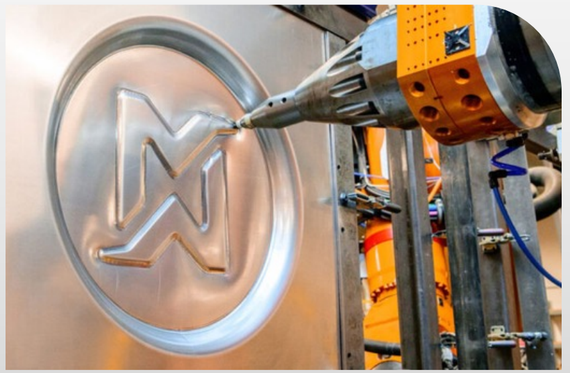


GrayMatter Robotics

- RaaS model
- Lower upfront costs
- Faster installations (2–4 months)
- Targets smaller US manufacturers

Standard Bots

- Intuitive setup (no code programming)
- Lowers implementation time
- Deploys for $5/hr



Machina Labs

- Flexible Factory Access
- Lease RoboCraftsman cells
- Improves speed of use, lowers CapEx
- Dev Suite for rapid PoC

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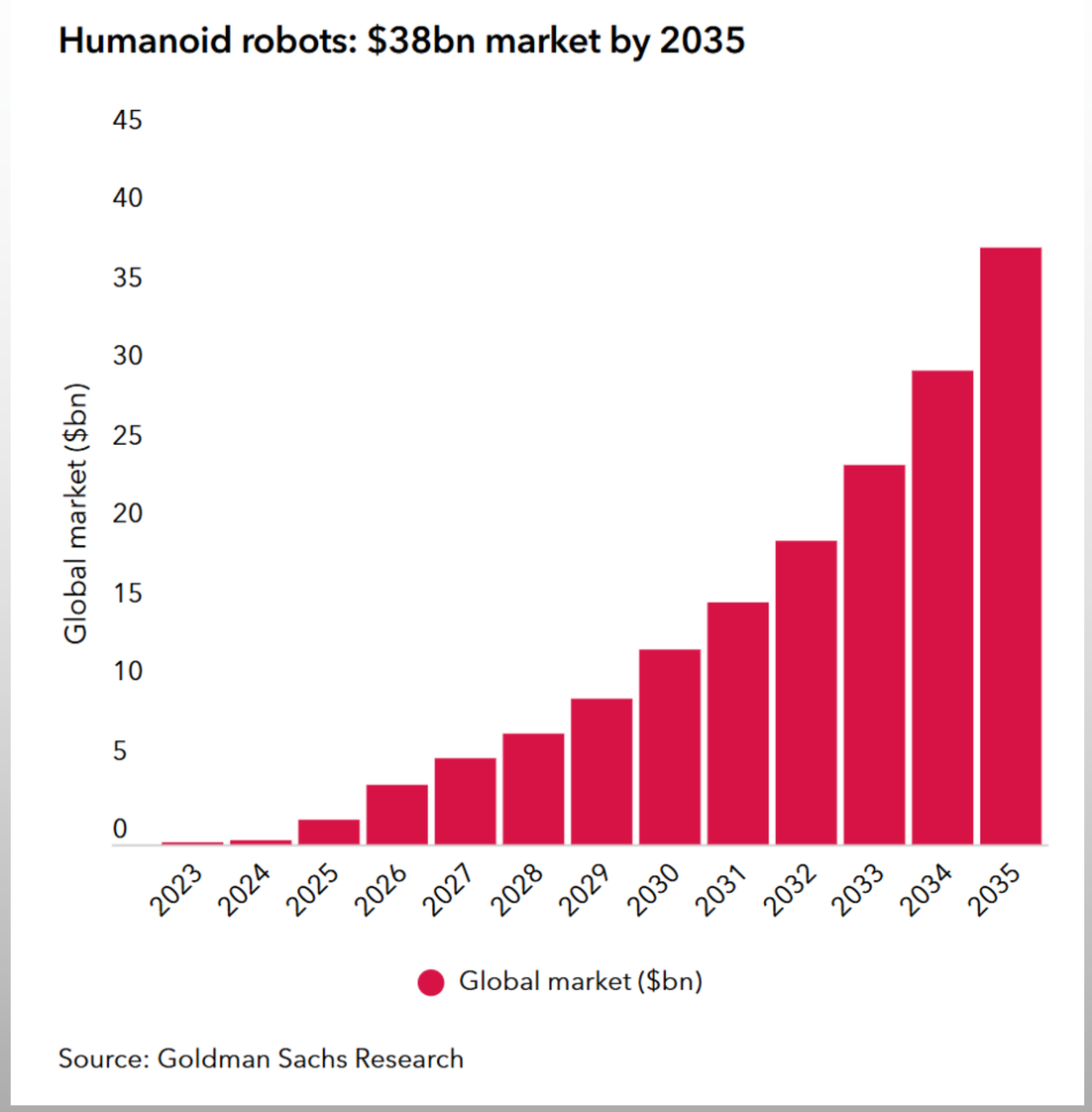
Source : The Wall Street Journal & Manufacturing USA



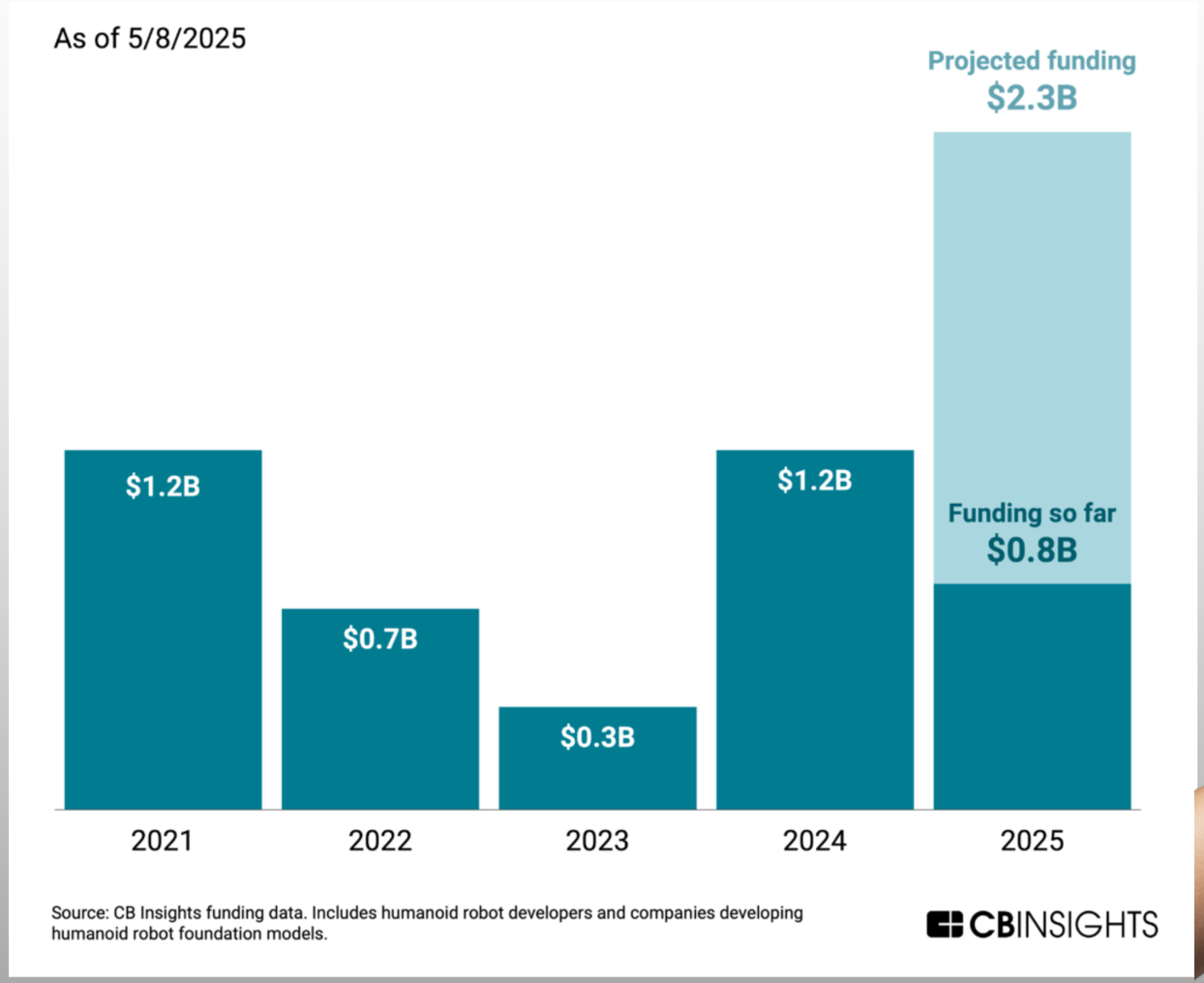
What happens when the humanoid robotics bubble bursts?

- **Market Projection**: Goldman Sachs forecasts the global humanoid robot market to reach $38 billion by 2035
- We are in an AI investment “bubble”
- There is heavy investment into general purpose humanoid robots with few practical applications

Source: Goldman Sachs

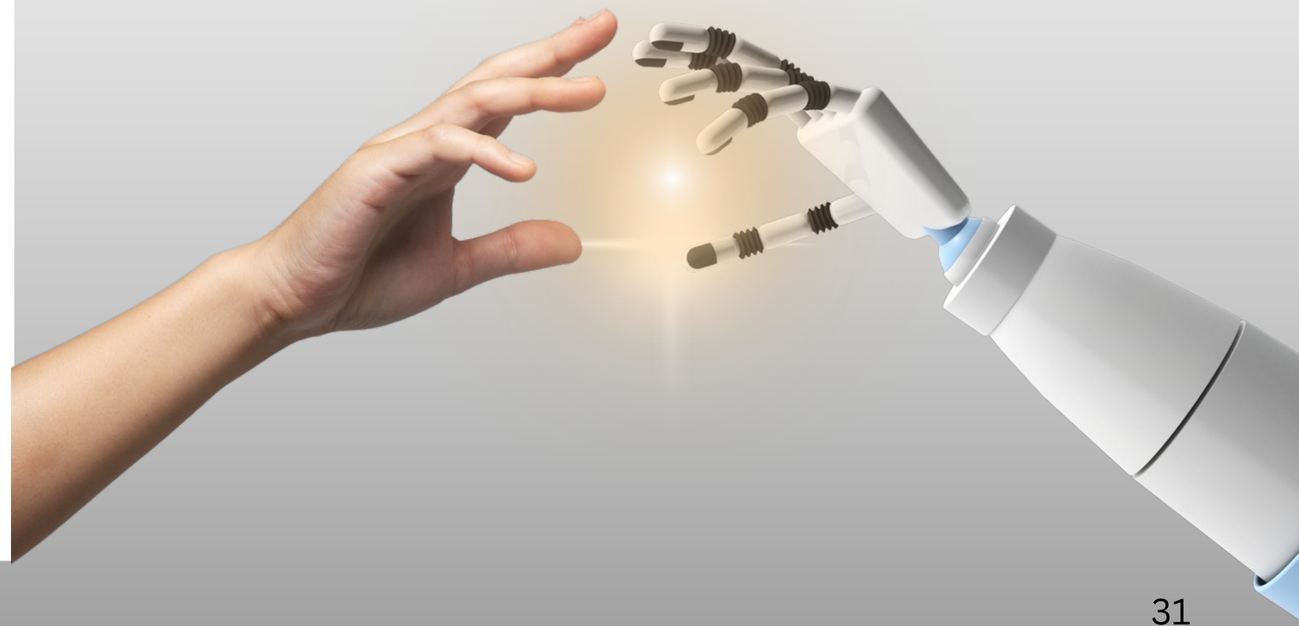
Is it worth the hype?

Humanoid Robotics Funding (2021–25)



In the short Term: **Probably Not**

In the long Term: **Maybe**



Humanoids on the horizon: the next 5 years

- Humanoid robots advancing but are limited by manipulation and dexterity requirements
- Widespread use cases for Humanoids are not yet defined with worthwhile ROI
  - As latency problems, computing power, and AI capabilities improve, ROI will be realized
  - Industry will adopt humanoid robots before home use
- A Lack of safety standards for humanoid robots creates a challenge for adoption

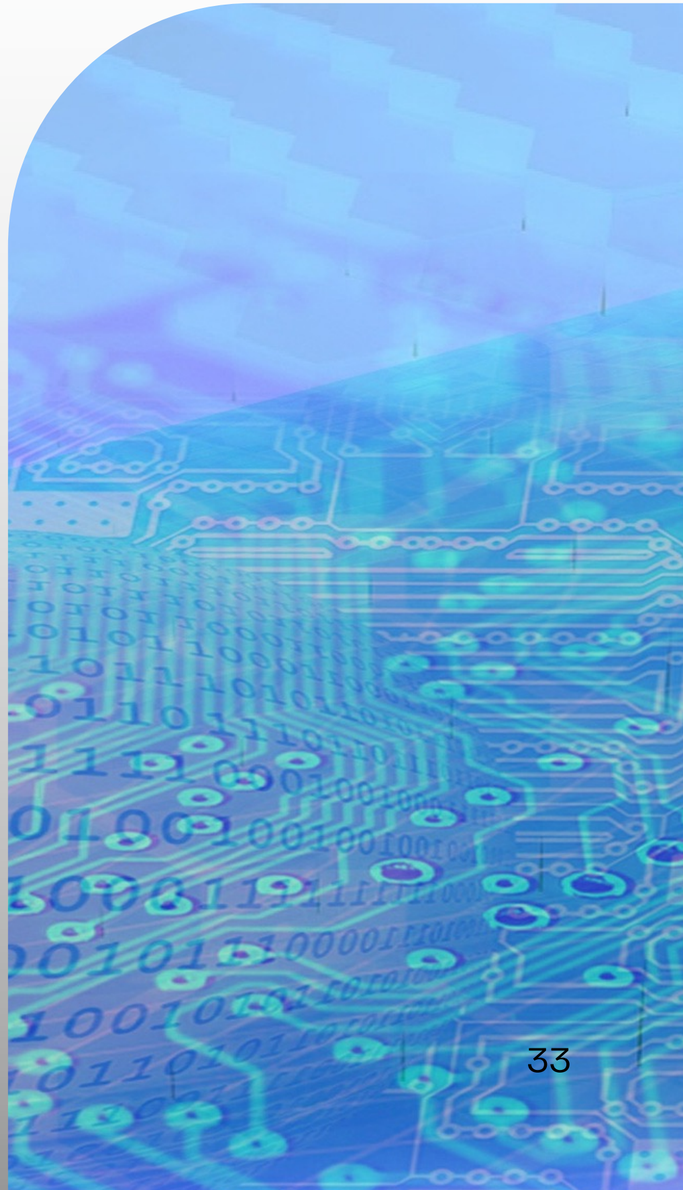
Idealistic perspective: "ROI is not the goal, adoption is the goal"

– Former Tesla Product Management Director

Realistic perspective: "ROI is the limiting factor to seeing these robots in industry"

– Principle Architect at Plus One Robotics

What could Intel do?



Strategic imperatives for Intel in physical AI & robotics

We recommend that Intel partners with a startup robotics company that has proven success in a specific niche in manufacturing. This requires balancing increasing capabilities with simplified integration processes that make your technology accessible to a broader range of developers and manufacturers.

Edge Computing Revolution

Develop denser, smaller chipsets with dramatically improved power efficiency for local processing that avoids cloud dependencies and communication delays.

Real-time Performance

Prioritize ultra-low latency features essential for physical movement control and direct sensor/actuator connections to minimize data transfer bottlenecks.

Strategic Partnerships

Collaborate with robotics startups by providing a Foundational model and computing needs, solving specific industry problems to accelerate integration.

Source : ACEEE & RoboDK

Strategic partnerships

Real-World Innovations

Case Packing and Palletizing Robotics company

Cutting edge robotics company using the RaaS model to remove high CAPEx burden

Robotics and Foundation Model Developer

Developer of essential foundational AI models for robotics

Robotic Welding Systems

SME in AI-powered robotic welding systems offering the RaaS model

Humanoid, Quadruped, And More

Chinese maker of humanoids, quads, arms, and LiDAR sensors

"Startups are going to **move faster, adapt quicker**, often bringing some kind of modular solutions. This is in contrast to legacy players who lack the clean data infrastructure, flexibility, and rapid iteration cycles" – Former Director of Product Management, Tesla

Recap

1. Manufacturing industry is evolving to embrace physical AI
2. Opportunities in hardware, software, and middleware
3. Factors impacting adoption
4. Specialized solutions are the way forward
5. Partner with start-ups

Thank you!