Towards general-purpose robots: connecting generative artificial intelligence to humanoids

Policy Presentation: Technology Roadmap for Europe and Beyond

GenAI and Robotics Are at the Point of Convergence

- Recent spectacular evolutions in GenAI
- Advanced **General purpose technologies empowering each other**
- lead to the Emergence of
  - **New complex robotics systems and systems of systems**
  - **New markets opportunities for robots**

Towards general purpose robots?

Humanoid robots are on a steep rise

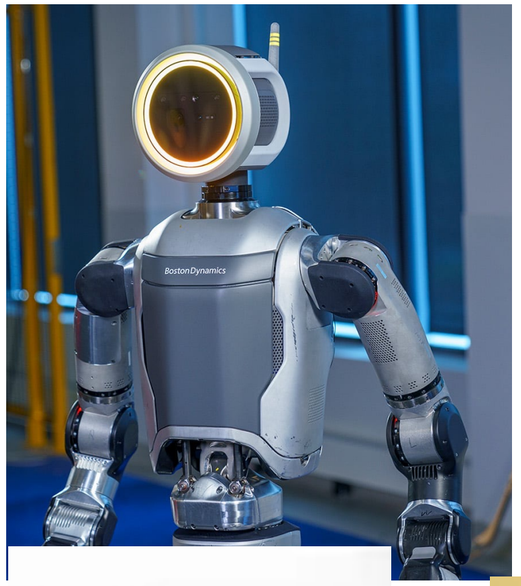
The market for humanoid robots represented $2.138 billion in 2022, and is estimated to reach **$18.193 billion by 2027** , with an average annual growth rate of **53.45%** over this period. North America is the continent with the greatest market potential. Asia-Pacific is the most mature market at this stage. In Europe, the CAGR is estimated at 51.2% from 2022 to 2027, reaching $3.92 billion by 2027.

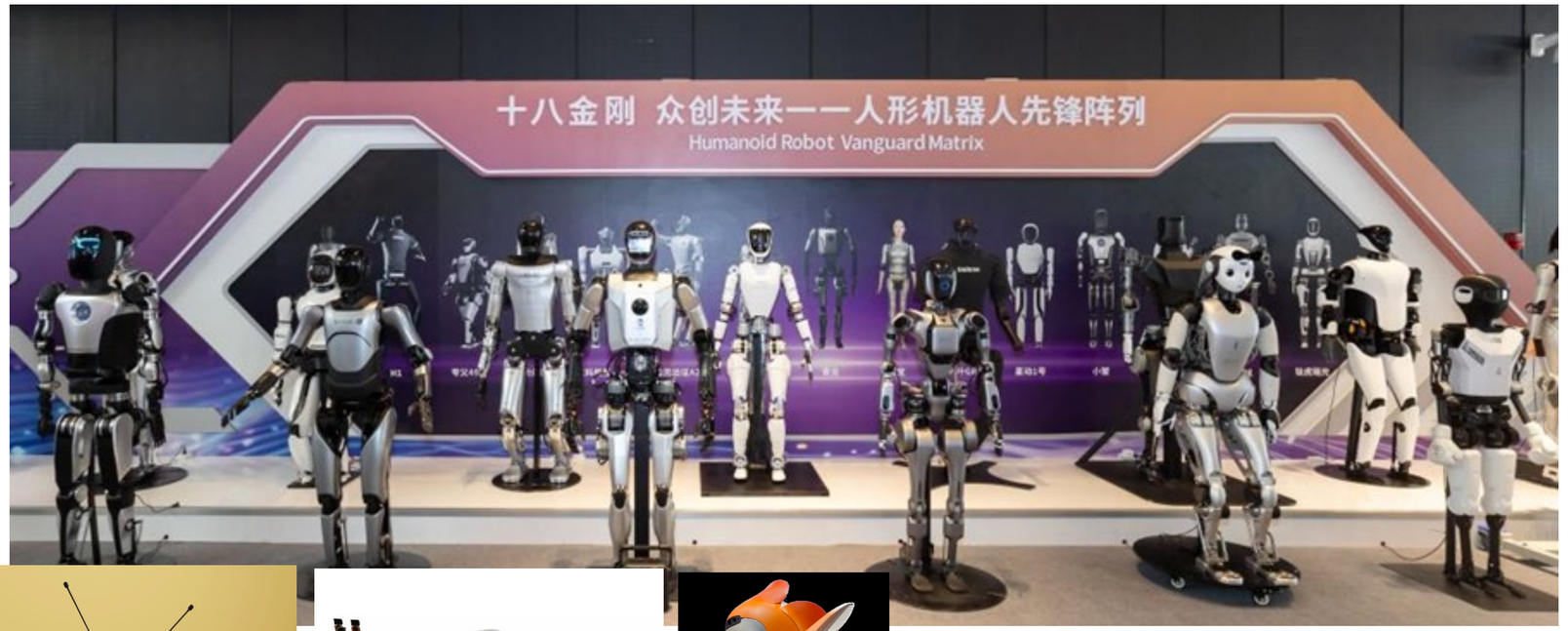
New-generation humanoid robots must combine the three major functions of “general purpose” robotics:

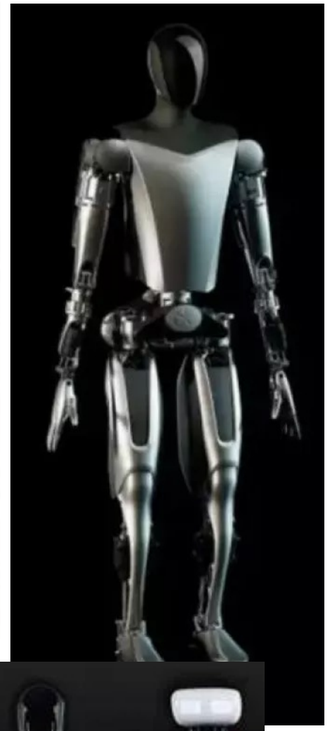
- **Interaction** (perception & real time analysis)
- **Manipulation** (Dexterity, multi-purpose)
- **Navigation** (unstructured environments; including social unpredictable ones)

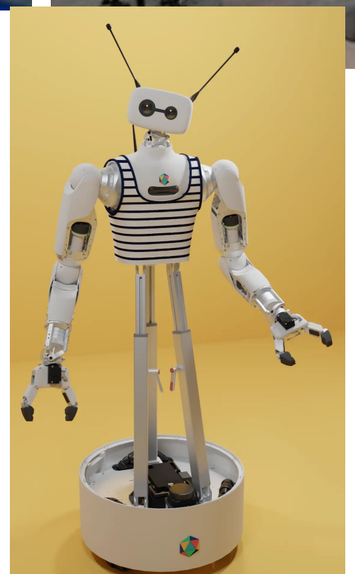
*Technavio's “Global Humanoid Robot Market 2023-2027” study estimated average annual growth rate**Data collected from the websites of each player and following a Factiva press review andplayer identification in market studies (Technavio, Statista, IDC, Forrester).Other key studies on the humanoid robotics market: Statista study on the global market for collaborative robots(2022); The Insight Partners study, Europe Exoskeleton Robotic System Market (2023)*

Humanoid robots : the race for world leadership is on!









General purpose robots capabilities

- learn how to perform a new task from scratch much more efficiently
- get better understanding of the environment, including social unstructured ones
- interact in a natural way with people and take their high-level commands
- achieve tasks in swarm through robot-to-robot interactions
- perform critical tasks in social environments
- manipulate any object, including deformable, in cluttered environments
- understand the object’s affordances and its environment;

We Need to Tackle Critical Challenges

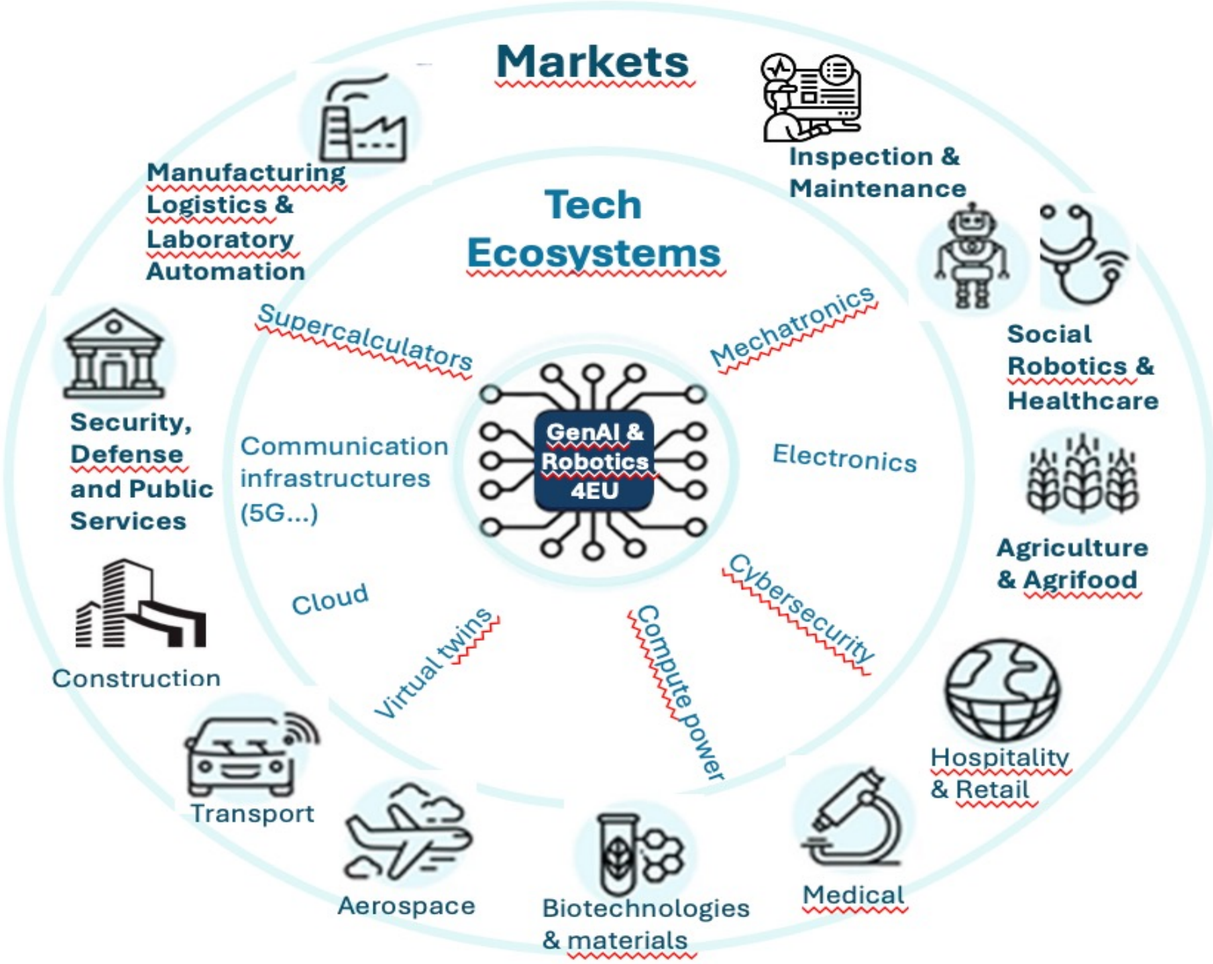
- **Safety**
  - Safety by design: testing in various generated situations
  - High-level of explainability, guarantees and/or certifications
  - Specific learning methods and wew approaches to keep the system within its operational bounds
- **Trustworthiness**
  - Explainability, reliability, cybersecurity
  - Quality
  - Embodiment and real-time interaction
- **Energy efficiency**
  - Enormous energy cost of learning and inference
  - Frugal AI to avoid exponential growth in data and computational requirements
- **Sustainability beyond energy efficiency and Alignment with values**

Multiple tech ecosystems to bridge the gaps and deliver general purpose robots to multiple markets

Bridge the **Sim-to-Real gap**
Bridge the **Robots - Datasets gap**
Bridge the **Robots-to-Humans gap**

AI embodiment is a necessary step towards General intelligence

Explore and interact with the **physical world**
Access to real-world **multimodal data**
Develop **adaptive intelligence**



Europe to leverage its strength and define its own path

1. Adopt a **Blue Ocean Strategy**

With specific criteria : Safety & Trustworthiness; Humanities and social sciences; Ethics (accessibility, privacy, …); Energy and data efficiency; Environmental impact; Reliability;

2. Educate, Train and Retain **Talents**

3. Build up a **Resilient and High-Performance Infrastructure** for Computation, Data, Connectivity and Provide Affordable Access to It

4. Fully Integrated Approach Between HW and SW Through the Entire Value Chain

5. Advancement in mechatronics to benefit fully from AI embodiment

6. Explore **Novel AI approaches**

7. Develop **Open Source** for Community Building, Digital **Commons** and Sovereignty

A fully integrated Hardware and Software approach

- **Modular mechatronic hardware components and system configurator**
- **Embedded sensor systems** with low consumption on board computers
- **Real-time and low latency AI solutions on the edge**, combining both AI accelerators at the edge for particular workloads (e.g., perception, planning) and focus on low-latency neural networks
- Development of **low energy consumption computer architectures** for training and inference, including the development of hardware efficient generative AI models
- Translate **large foundational models efficiently on the edge** for both privacy and performance reasons
- **Full Stack Simulator** for training and validation of complex AI models and robotic applications

Thank you

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