

Embodied AI Standardization: Chinese approach

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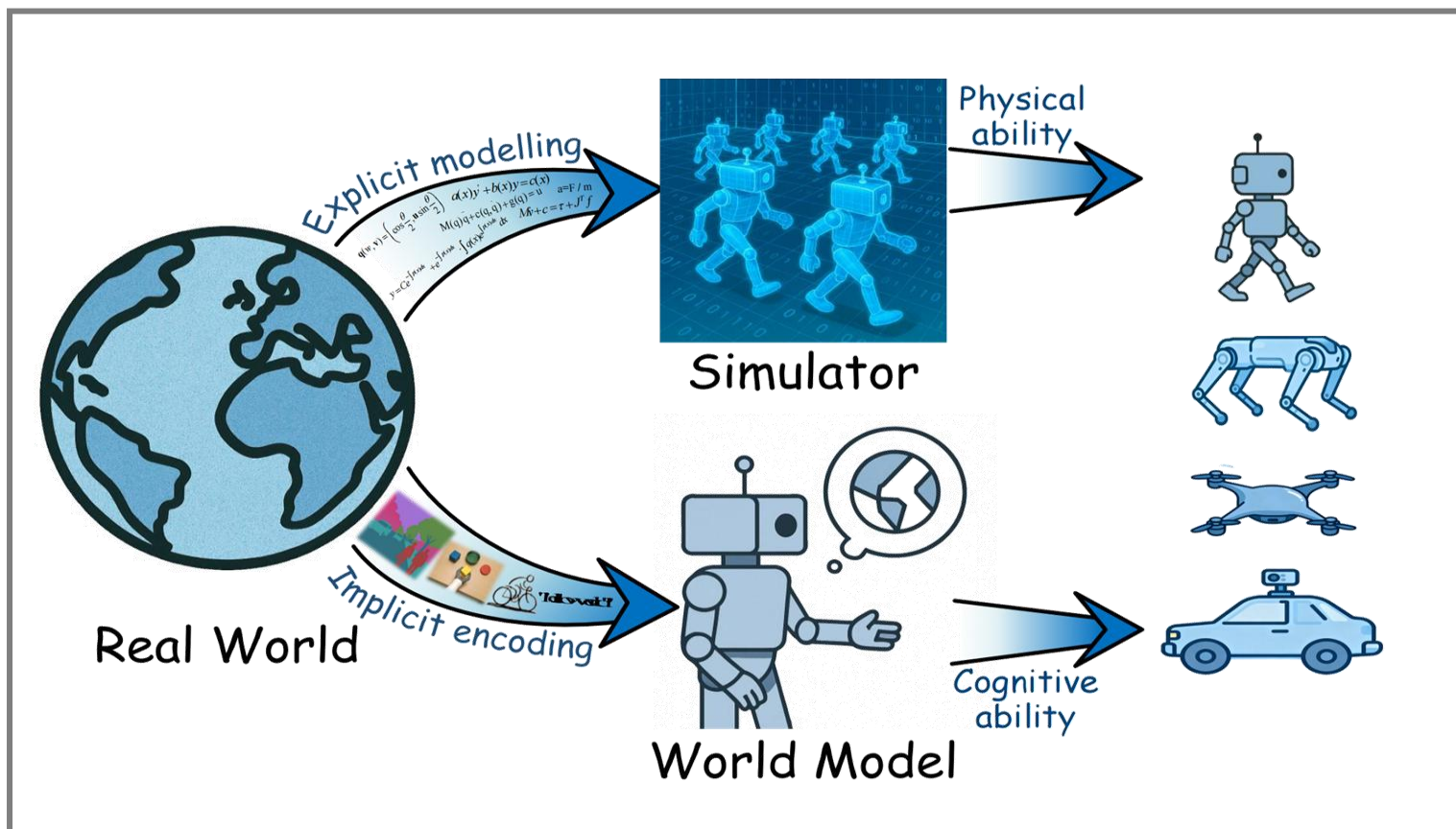
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1. Physical AI, also referred to as embodied AI
2. Technical Challenges
3. The Role of Standardization

Embodied AI and Physical AI almost align in key features.



What it is ?

AI + physical body

How it works ?

interact with the physical world

Where it applies ?

robots, autonomous vehicles (AVs) and other physical systems.

What it can do ?

perception, cognition, and action

Subtle differences:

- Physical AI emphasizes the **simulation and understanding** of physical laws.
- Embodied AI emphasizes **act autonomously** and **adapting** to the physical world



Embodied AI refers to the integration of artificial intelligence into physical systems, enabling them to interact with the physical world. These systems can include general-purpose robots, humanoid robots, autonomous vehicles (AVs), and even factories and warehouse facilities.

Physical AI lets autonomous systems like cameras, robots, and self-driving cars perceive, understand, reason, and perform or orchestrate complex actions in the physical world. Physical AI is unlocking new capabilities that will transform every industry like robots, autonomous vehicles (AVs) and smart space.

Known as physical AI or embodied AI, this convergence of robotics and artificial intelligence is poised to redefine how machines interact with humans and their environments.

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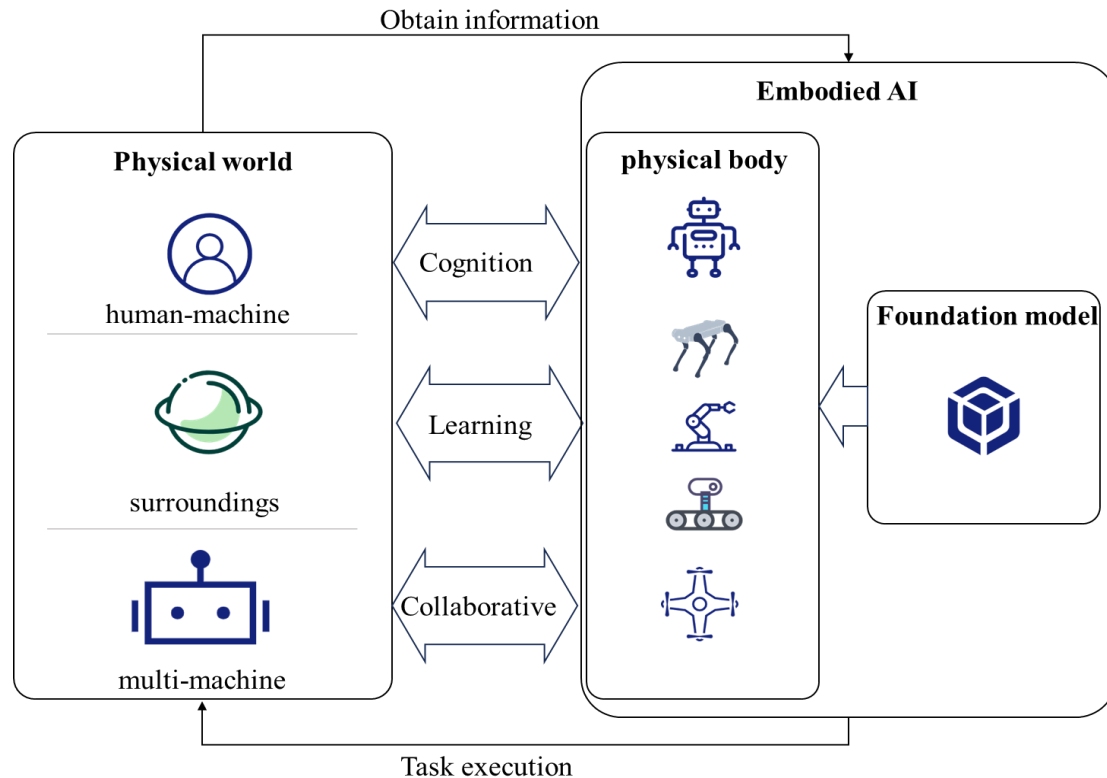


Center for Research and Development Strategy
Japan Science and Technology Agency

"Physical AI" refers to embodied artificial intelligence that acquires and develops intelligence through direct interaction with the physical environment via components such as sensors and actuators.



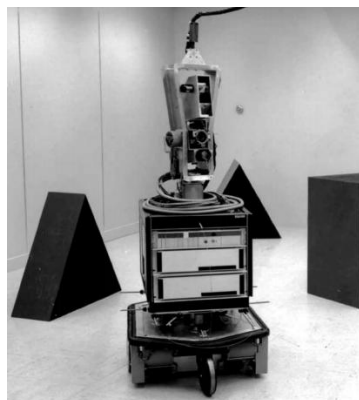
Conceptual diagram and key features



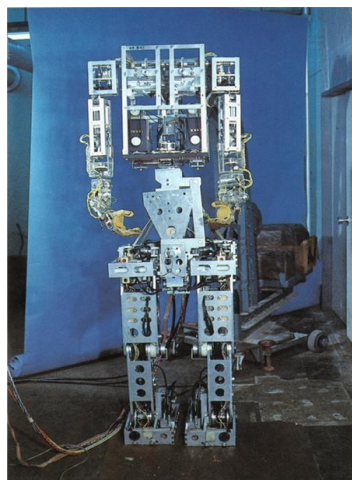
Definition

Embodied artificial intelligence(EAI): Artificial intelligence integrated into physical systems that interact autonomously with, and adapt to the physical world.

ITU-T F.RF-EAI “Requirements and framework for embodied artificial intelligence systems”



1961 Shakey



1973 WABOT-1



1999 AIBO



2000 ASIMO



Robot

- Programmed

Smart Robot

- Sensory & Execution

Embodied AI

- Sensory & Execution
- Cognition
- Collaborating
- Learning

Humanoid Robot

- Robot with body, head and limbs
- looking and moving like a human

Embodied AI is a transformative shift in AI that integrates AI into physical systems, enabling them to interact with and learn from their environment through sensory inputs and actions.

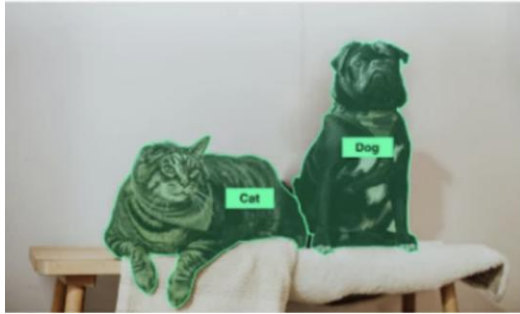
Aspect	(Non-embodied) AI (ChatGPT, Image Recognition program)	Embodied AI (Robots, Self-driving Cars)
Form of Existence	"A Brain in a Vat": Pure software, residing on servers.	"An Embodied Brain": Software integrated with a physical body.
Primary Goal	Process information in a digital space; passively waits for input (e.g., a prompt).	Take action in a physical environment; acts proactively based on the situation.
Input/Output	Data (text, images, speech)/Data (generated text, classification labels)	Perception (sensor data, cameras, LiDAR, touch)/Action (movement, manipulation)
Learning Paradigm	Learns from static datasets: Trained by analyzing massive existing collections of images and text.	Learns through interaction & experience: Learns like an infant, through trial and error, touching, observing, and failing.

Embodied AI = AI + Physical Body (Action)

Embodied AI enables robots from automation to autonomy, allowing them to performs behaviours or tasks independently, learn, and adapt to changing environments.

Perspective	Robotics	Embodied AI
1. From "Programming" to "Learning"	All behaviors are based on explicit code written by programmers.	Abilities are acquired through real-time environmental interaction (trial-and-error) .
2. From "Perception for Action" to "Perception-Cognition-Action"	Sensory data is used directly to execute predefined actions. e.g., verifying workpiece position, performing force-controlled assembly.	Sensory data is used to construct an internal model of the world, (e.g., "This is a messy room") and object properties, enabling actions driven by cognition .
3. From "Closed World" to "Open World"	The environment and all variables (e.g., object location, lighting, process) must be predictable and pre-defined.e.g., verifying workpiece position, performing force-controlled assembly.	Its purpose is to cope with environments, and must handle unseen objects, adapt to dynamic changes, and deal with ambiguity .

Embodied AI = Robots + Brain (Cognition)



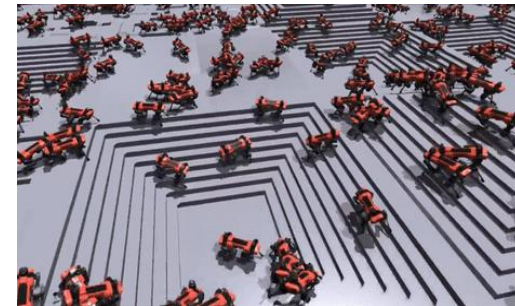
Recognition



1.Cognition



Programming



2.Learning



Isolated



3.Collaborative

Growing Market

\$ 38 Billion

by 2035^[1]

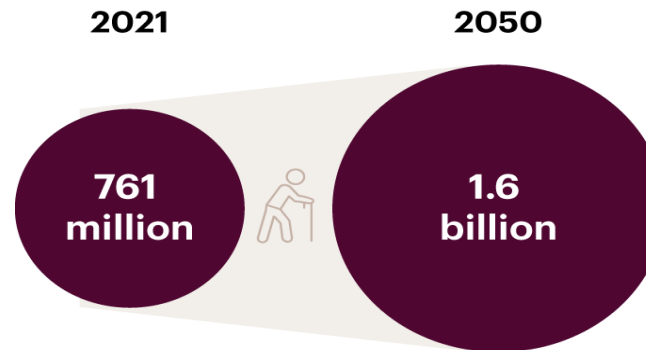
1 Billion in Use

by 2050^[2]

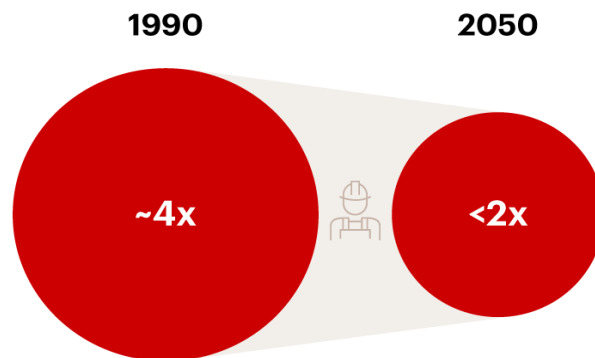
— only for humanoid robots

Societal Needs^[3]

Elderly Care Crisis



Labor Shortage



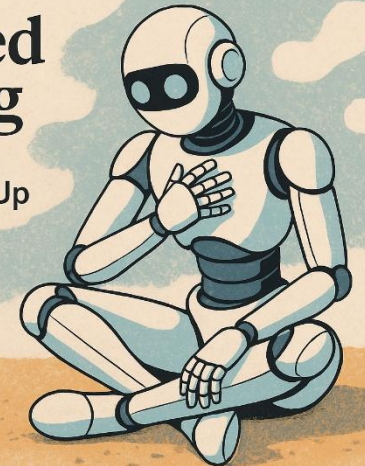
The way towards AGI

读万卷书，行万里路

Read ten thousand books, travel ten thousand miles.

Embodied Learning

Rethinking AGI from the Ground Up



[1]Goldman Sachs, Jan, 2024, *Global Automation: Humanoid Robots – The AI Accelerant*

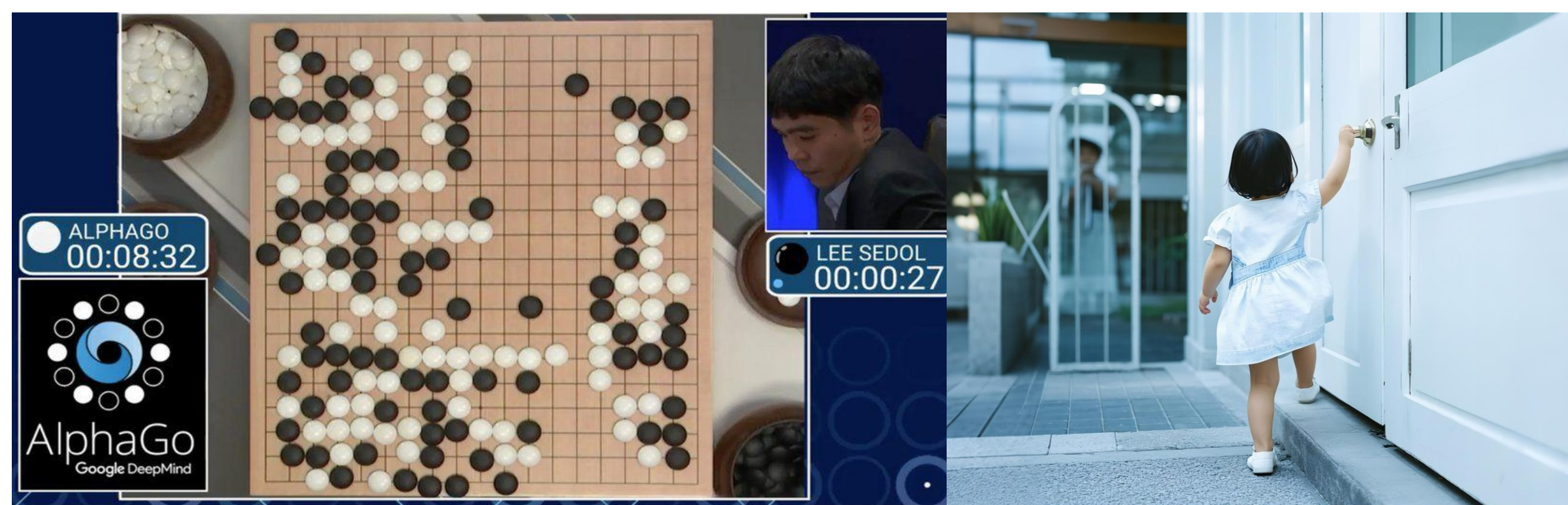
[2]Morgan Stanley, May 2025, *Humanoids: A \$5 Trillion Market*

[3]UN Department of Economic and Social Affairs & International Labor Organization

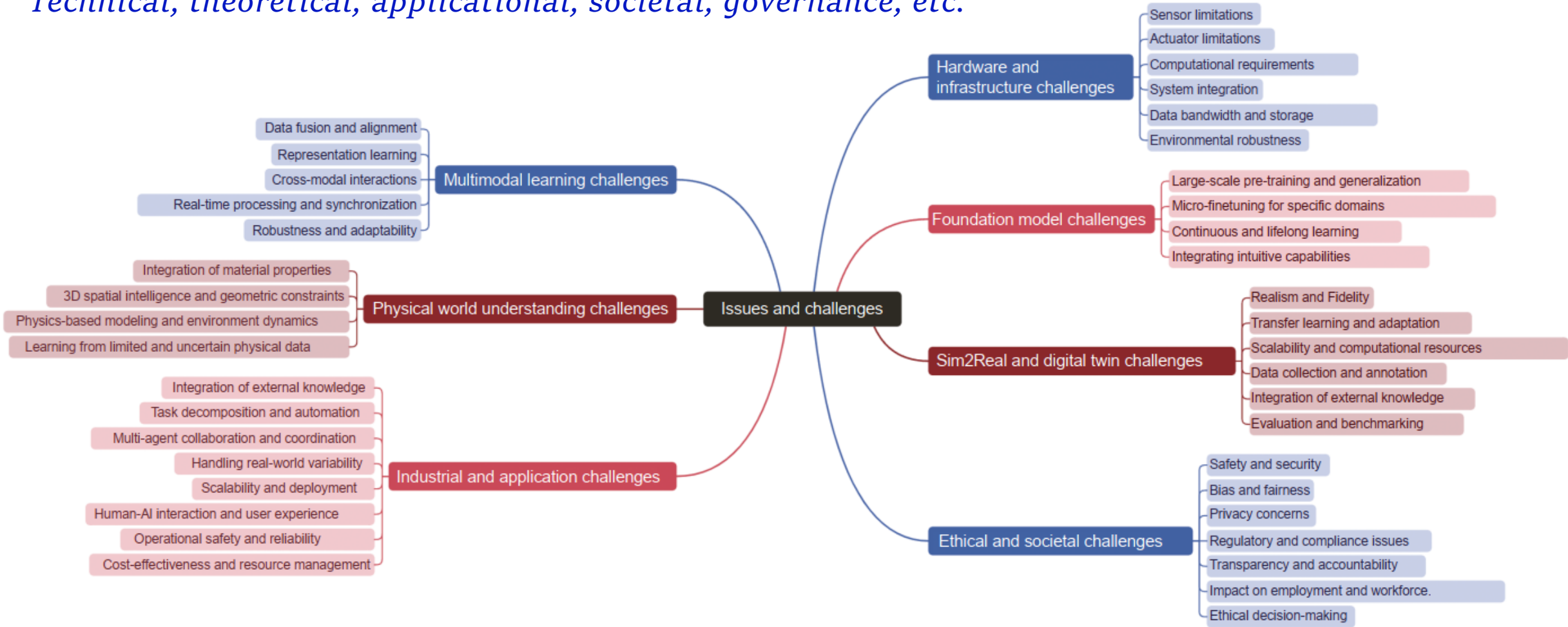
1. Physical AI, also referred to as embodied AI
2. Technical Challenges
3. The Role of Standardization

“It is comparatively easy to make computers exhibit adult level performance on intelligence tests or playing checkers, and difficult or impossible to give them the skills of a one-year-old when it comes to perception and mobility.”

—Hans Moravec, 1988



Technical, theoretical, applicational, societal, governance, etc.



Sources: Sun F, Chen R, Ji T, et al. A comprehensive survey on embodied intelligence: Advancements, challenges, and future perspectives[J]. CAAI Artificial Intelligence Research, 2024, 3: 9150042.

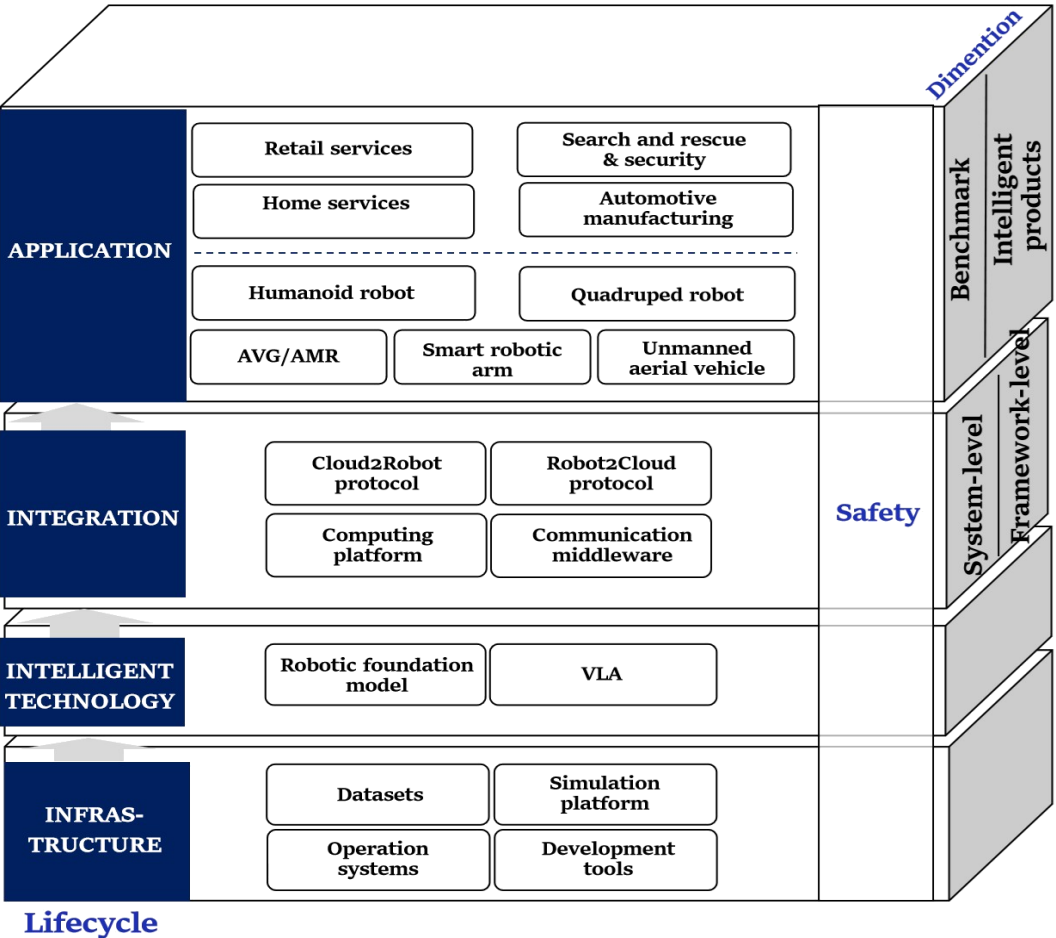
1. Physical AI, also referred to as embodied AI
2. Key Challenges
3. The Role of Standardization

Dimension	Key Challenges	Standardization Directions
1. Data & Perception	• Heterogeneous multimodal and multimedia data • Lack of high-quality, task-specific datasets	• Format and quality standard for Multimodal training data • Benchmark dataset & annotation specifications
2. Network & Collaboration	• Complex task allocation across cloud-edge-device • Lack of common multi-agent communication protocols	• Unified interfaces for collaborative computing • Standardized real-time agent interaction protocols
3. Model & Evaluation	• No unified benchmarks for embodied models	• Assessment criteria and metrics • Standardized performance benchmarks
4. System Integration	• High complexity in integrating heterogeneous components • Poor interoperability between vendors	• Modular development frameworks • Plug-and-play component & middleware standards
5. Human-Robot Interaction	• Lack of safety protocols for physical HRI • Inconsistent user interfaces and experiences	• Safety standards for physical interaction • Human-centered design guidelines
6. Safety & Security	• Data privacy and protection risks • Lack of algorithmic transparency and explainability	• End-to-end security & privacy frameworks • Standards for explainable EAI & audit trails
7. Ethics & Governance	• Ambiguity in accountability and liability • Risk of value misalignment	• Accountability & liability frameworks • Ethical guidelines & compliance standards



Artificial Intelligence Standardization Technical Committee of the Ministry of Industry and Information Technology

MIIT/TC1 has developed a standardization roadmap for EAI



- **Application** Capability requirements for embodied artificial intelligence home companion products
- **Application** 2024-1328T-YD The benchmarking and assessment method for embodied artificial intelligence
- **Safety** Requirements for risk prevention capabilities in human-machine interaction of embodied artificial intelligence systems
- **Data** Capability assessment guide for embodied artificial intelligence training grounds
- **Data** 2024-1329T-YD Dataset quality requirements and evaluation methods of embodied artificial intelligence

EAI Bench: **Industry-oriented** embodied AI benchmark: tackling diversity scenarios, disunified tasks, and inconsistent evaluation criteria.

ONE Assessment Standard

ONE Set of Test Tasks

Standardized Testing
Environment

Jointly built with industry under unified data standards to ensure the assessment tasks are scalable, industry-relevant, and widely applicable.

The first co-built Test datasets **cover 2,000 test tasks**, covering **300 task types** across **manufacturing, household, retail, and logistics** scenarios.

Goal: Co-develop an industry-oriented test set with a unified evaluation criterion, conducting real-world assessments in a standardized environment to accelerate embodied AI from training to practical use.



Contributions from the industry

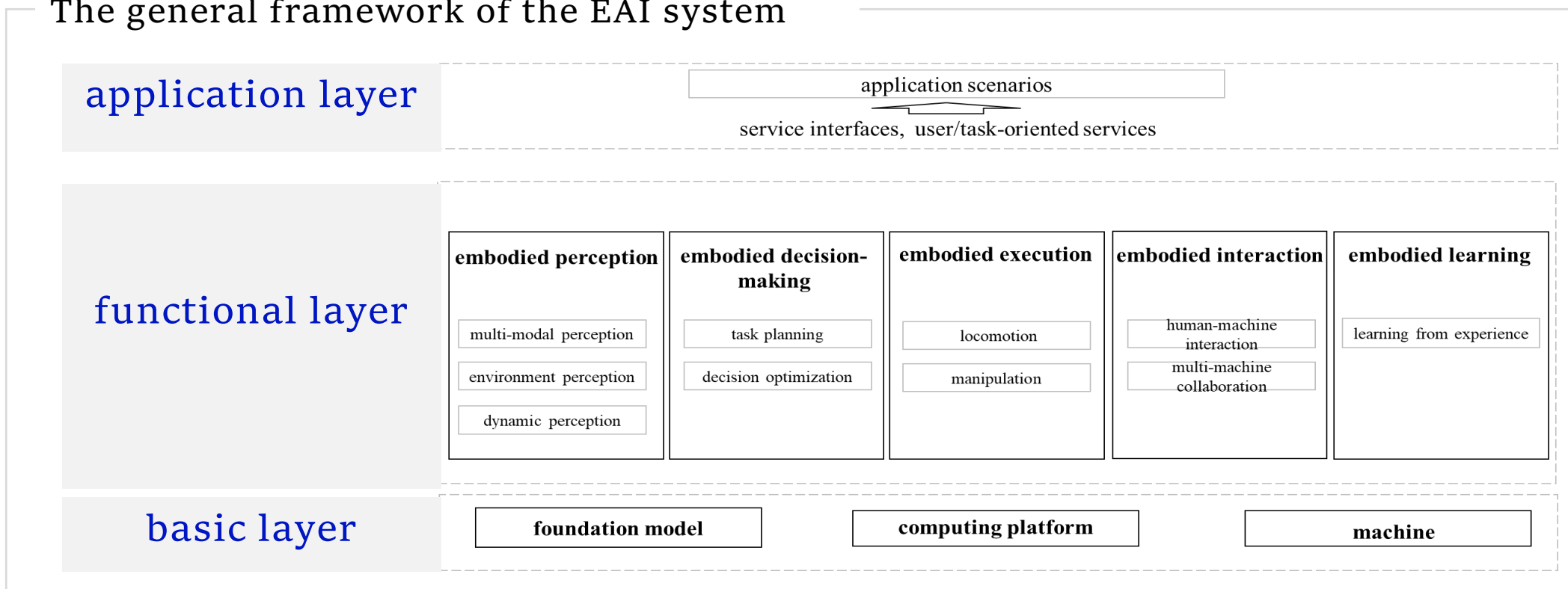


ITU-T SG21

ITU-T is focusing on EAI and has started working on standards.

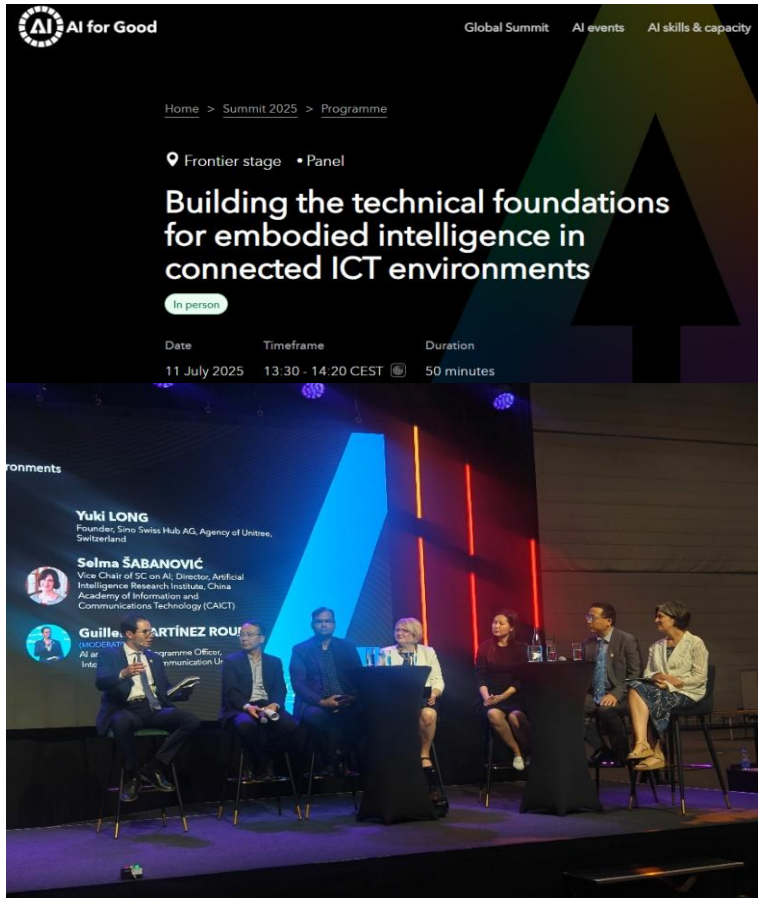
- ITU-T F.748.66 Requirements and framework for embodied artificial intelligence systems
- ITU-T F.TR-ED Technical requirements for embodied artificial intelligence teleoperation data collection systems in real-world scenarios
- ITU-T F.BA-EAI Framework for benchmarking and assessment of embodied artificial intelligence systems

The general framework of the EAI system

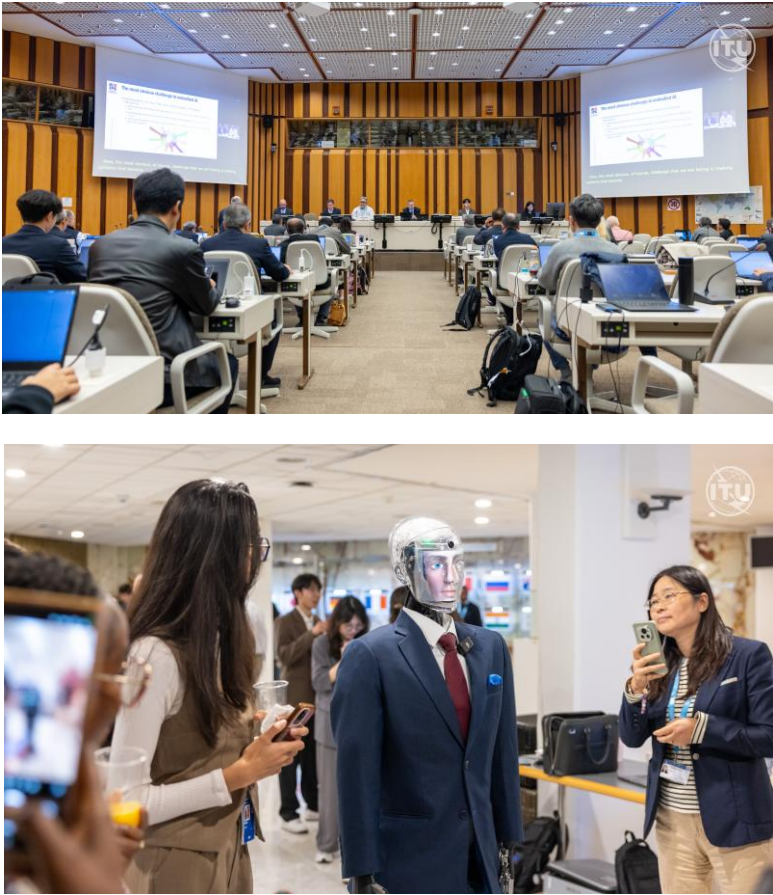


from ITU-T F.748.66

AI for Good Pannel

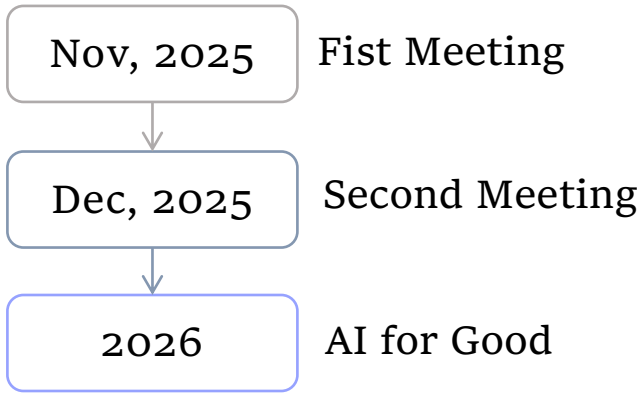


Embodied AI Workshop



AHG-EAI

Explore possible approaches to advancing Embodied AI standards or pre-standards work.



Standards are essential in translating the values we agree on as a global community into real-world systems. Standards should not be construed as constraints on innovation.

- Embodied AI represents a promising pathway toward AGI that goes beyond the current domains of AI and robotics, with the potential to benefit humanity greatly.
- Moravec's paradox is still valid; EAI faces significant challenges, some of which can be effectively addressed through standardization.
- International cooperation in embodied intelligence standards is crucial.
- I hope to continue the discussions on EAI international standards at the International AI Standards Summit in Korea next month.

Thanks

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