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PHYSICAL AI

Applications, Industrial Transformation and Challenges

1. Latest Developments

The deployment of Physical AI is gaining momentum as companies increasingly integrate AI-powered autonomous systems into industrial operations. Applications range from robotics and predictive maintenance to energy exploration and automated manufacturing.

2. About Physical AI

Physical AI refers to the application of artificial intelligence to autonomous systems that can perceive, understand and perform complex actions in the physical world.

- It combines AI models with sensors, actuators and control systems, enabling machines to interact with and respond to real-world environments.
- Unlike conventional AI applications that operate primarily in digital environments, Physical AI enables systems to move beyond software-based tasks and perform physical actions.

For example, traditional industrial robots are generally programmed to perform predefined tasks in controlled environments, such as repeatedly welding the same section of an automobile. In contrast, AI-enabled robots can use broader contextual understanding to adapt to different situations and perform more complex tasks.

Physical AI can be applied to individual robots as well as larger systems, including AI-powered factories, smart energy grids and fleets of autonomous vehicles.

3. Evolution from Generative AI to Physical AI

Generative AI models such as ChatGPT and Meta's Llama are primarily trained on large volumes of text and image data. They can generate language, visuals and abstract concepts but have limitations in understanding physical environments and real-world interactions.

Physical AI seeks to overcome these limitations by integrating AI models with multimodal inputs, including:

- Images and videos.
- Text and speech.
- Real-world sensor data.
- Spatial and environmental information.

These inputs enable autonomous machines to understand their surroundings, interpret physical conditions and execute appropriate actions.

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Physical AI also combines large language models (LLMs) with reinforcement learning and specialised training. This allows robots to develop general contextual understanding alongside task-specific capabilities.

Real-world data is particularly important because synthetic data alone is insufficient to train machines for complex physical environments. Robots need exposure to actual operating conditions and multiple sensory inputs to improve their performance over time.

4. Real-World Industrial Applications

Physical AI is increasingly being deployed across the energy, manufacturing and logistics sectors.

Energy and Oil Industry

Several major energy companies are integrating AI into their operations:

- ADNOC: The Abu Dhabi state-owned oil company has partnered with G42 and OpenAI to deploy advanced AI capabilities across its operations, focusing on operational efficiency and complex engineering challenges.
- Shell: It has implemented a predictive maintenance system with C3.ai to monitor more than 13,000 pieces of equipment, helping prevent failures and reduce emergency repair costs.
- BP: It uses AI to analyse real-time drilling data and optimise drilling parameters. The company has reported a 7% reduction in exploration and drilling costs and an approximately 8% reduction in non-productive time.
- Chevron: Its AI-powered seismic interpretation system, ApEX, uses multiple search agents to improve subsurface imaging and assess potential drilling sites.

Manufacturing and Robotics

Taiwanese electronics manufacturer Foxconn has begun deploying AI-powered robotic systems to address rising labour costs and changing manufacturing requirements.

By combining AI with digital twin technology, the company simulates and automates complex tasks such as screw tightening and cable insertion.

Reported outcomes include:

- Nearly 50% reduction in deployment time for new systems.
- 20–30% improvement in robotic cycle times.
- 25% reduction in error rates.

These applications demonstrate how Physical AI can improve manufacturing precision, operational efficiency and production flexibility.

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5. Physical AI and the Monetisation Challenge

One of the major reasons behind the growing interest in Physical AI is the AI industry's challenge of converting technological capabilities into sustainable revenue.

Although generative AI has attracted significant investment, monetisation remains a concern for technology companies. Physical AI offers an opportunity to deploy AI in industrial environments where measurable improvements in productivity, maintenance, operational efficiency and cost reduction can generate commercial value.

Partnerships between AI companies and industrial organisations, such as the OpenAI-G42-ADNOC agreement, reflect this shift towards enterprise applications.

According to McKinsey estimates, robotics and Physical AI could generate at least US$1 trillion in economic value between 2026 and 2040, primarily across manufacturing and logistics.

The economic impact may extend beyond replacing workers or improving productivity. It could transform how products are designed and manufactured and how responsibilities are distributed between humans and automated systems.

6. Challenges in Deploying Physical AI

- Dependence on real-world data: Physical AI systems require extensive data from actual operating environments. Capturing and integrating multiple sensory inputs remains a significant challenge.
- Complexity of physical environments: Unlike digital systems, real-world environments are dynamic and unpredictable. Machines must respond safely and accurately to changing conditions.
- Integration with industrial infrastructure: Deploying AI-powered robots requires integration with existing machinery, sensors, control systems and operational processes.
- Commercial viability: Companies must demonstrate measurable returns on investment through reduced costs, improved productivity and better operational outcomes.

Source: The Indian Express (IE)