CHINA AI ROBOTICS

Expert call on Frontier Foundation Models in Physical AI & Embodied Robotics

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As frontier LLMs expand into physical AI, their emergent zero-shot generalization capabilities increasingly position them to operate as the centralized cognitive 'brain' for embodied robotics. On 28 Oct, we hosted a Robotics Algorithm Engineer at a top-tier AI research institution, currently focused on embodied VLM/VLA algorithms and with prior experience in 3D reconstruction and spatial interaction, for an expert call with investors.

Key implications in our view post the expert call:

- **An acceleration rather than an overnight inflection:** Future advancements in high-precision 3D perception and low-latency processing are unlocking significant leaps in zero-shot and few-shot generalization for frontier foundation models which is bridging the gap toward commercial viability and accelerating real-world deployment schedules.
- **Shifting moats toward edge and hardware integration:** Because frontier AI laboratories face non-trivial barriers when descending into embedded hardware and on-device execution layers, some robotics OEMs must reposition their moats. Long-term competitive differentiation will increasingly center on rapid edge-model deployment, robust compute optimization, and seamless hardware-software co-design.
- **Upstream data infrastructure as near-term beneficiaries:** As physical AI scales, surging demand for multimodal real-world interaction data positions collection and sensing hardware—particularly advanced 3D spatial sensors and high-resolution tactile arrays—as prime near-term beneficiaries, with data fidelity remaining the critical operational bottleneck.
- **Not just about Humanoids but also Industrial Automation & Cobots:** While bipedal humanoids command public mindshare, the potential combination of foundation models with collaborative robots (cobots) and brownfield industrial automation could also represent more practical factory solutions that requires precision and reliability.

Stock ideas: Prefer attractively valued supply chain stocks with solid fundamentals and AI robotics upside: Buy Inovance on its positioning across



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humanoid components/modules and AI-enabled automation hardware with sensing/data-collection capabilities, supported by its broader strengths in industrial automation and motion control. **Buy Sanhua-H** on potential actuator-assembly exposure to North American robot customers, alongside its core leadership in global EV thermal management and HVAC components. **Buy Shuanghuan** on its precision-gear leadership and expanding exposure to humanoid/AI robotics, with AI robotics revenue expected to more than double to Rmb400-500mn in 2027E. **We stay Neutral on Sanhua-A and LeaderDrive mainly on valuation;** for Sanhua-A, we prefer Sanhua-H given the H-share valuation discount, while for LeaderDrive we remain positive on harmonic reduction-gear TAM expansion across humanoid/service and industrial robots but see valuation as limiting upside.

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Key discussion topics on the expert call

1. Frontier Foundation Model Capabilities and Architectural Evolution

- **Step-change in task generalization:** The primary breakthrough in latest-generation frontier foundation models is their transition beyond narrow "out-of-domain" (OOD) adaptability—such as varying an object's color, texture, or basic geometry—toward true zero-shot and few-shot task generalization. Models can increasingly be deployed across novel environments and unstructured conditions without requiring scenario-specific fine-tuning.
- **Three critical engineering bottlenecks:**
  a. *Spatial 3D perception:* While depth representations have matured materially, current spatial fidelity remains insufficient for millimeter-level physical interactions, causing closed-loop execution to suffer from repeated trial-and-error cycles.
  b. *Inference latency:* End-to-end execution frequencies remain too slow for real-time dynamic stabilization, high-speed manipulation, and microsecond-level reflexive recovery.
  c. *Inference economics:* Widespread commercial deployment requires progressive model distillation, transferring high-level physical reasoning and spatial awareness from frontier-scale clusters down into optimized, parameter-efficient edge models.
- **The System 2 vs. System 1/0 architectural division:**
  - **Supervisory role of System 2:** High-level models operate primarily as a cognitive supervisor—either outputting waypoint and semantic action primitives directly to System 1 or monitoring and correcting System 1 trajectories in real time.
  - **Frontier labs gated from low-level control:** Frontier AI laboratories are unlikely to descend into System 1 (reflexive motion planning) or System 0 (microsecond actuator torque control) in the near term. Physical embodiment

presents distinct electromechanical dynamics, hardware-specific kinematics, and protracted iteration cycles involving real-world stress testing, physical component fatigue, and mechanical repairs. These hardware constraints contrast sharply with the hyper-accelerated, software-only evaluation cycles of digital large language models (LLMs), making direct System 0-level control a less natural extension for pure software labs.

2. Strategic implications for the robotics ecosystem

- **The generalization vs. precision trade-off:** Commercial robotics currently faces a structural divide: systems achieve either high generalization across unstructured domains or near-100% deterministic precision within rigid silos, but rarely both. Because mission-critical industrial manufacturing demands six-sigma reliability and microsecond repeatability, industrial robotics will continue to rely on domain-specific datasets and deterministic kinematics. Conversely, frontier foundation models unlock variable, non-standardized commercial, logistics, and domestic service environments where adaptability outweighs sub-millimeter precision.
- **Repositioning OEM moats around hardware abstraction:** With frontier foundation models establishing third-party cognitive dominance, the primary defensible moat for robotics OEMs shifts downward toward System 1/0 execution. Long-term differentiation depends on developing robust real-time control operating systems, safety compliance architectures, and standardized API/SDK abstraction layers that enable external foundation models to command the underlying hardware seamlessly.
- **Geopolitical and supply chain dynamics:** Overseas leadership at the frontier foundation-model layer does not inherently displace domestic or Chinese embodied-AI hardware players. Once a viable cognitive architecture is proven, OEMs that excel in precision mechatronics, high-yield manufacturing, and System 1 motion integration can capture significant terminal value, even if the high-level cognitive "brain" is sourced from third-party foundation model providers.

3. Industry maturity: "ChatGPT moment" vs. accelerated evolution

- **An acceleration rather than an overnight inflection:** Rather than representing an instantaneous operational tipping point, frontier models function as a powerful catalyst. By solving generalized semantic scene understanding and broad task planning, they pull forward the commercialization timeline for complex, unstructured domains (most notably domestic home assistance and high-variability logistics) that were previously deprioritized or confined to scripted demonstrations.
- **Benchmarking against Autonomous Driving (AD):**
  - *Maturity Phase:* When measured against safety-critical, production-grade reliability metrics, general-purpose robotics manipulation remains nascent—tracking closer to pre-2015 or roughly 2017–2018 stage autonomous vehicle development.
  - *Velocity of Progress:* However, the compounding rate of technical progress is