Inference-Time Compute

inference-time-compute · compute · concept

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Summary

The scaling regime in which model capability is increased by spending more compute at inference time (multiple samples, search, longer reasoning chains, tool-using iteration) rather than by training a larger model — disrupting the training-compute-as-capability-proxy assumption underlying most current AI governance.

At a glance

Used by

1 instrument(s)

Related concepts

compute-threshold, frontier-tier, capability-elicitation, model-distillation-risk, agentic-system

Primary source

Snell, C., Lee, J., Xu, K., Kumar, A. (2024), 'Scaling LLM Test-Time Compute Optimally can be More Effective than Scaling Model Parameters' — establishes inference-time-compute scaling as a first-class capability lever.

Details

The dominant assumption underlying compute-threshold regulation (EU AIA Art. 51, US EO 14110 §4.2(a)) is that training compute correlates with deployment capability. Inference-time-compute scaling complicates this: a model trained at compute level C can be deployed with inference-time compute K·C per response, producing capability properties intermediate between the base model and a model trained at K·C. OpenAI's o1 (Sep 2024) and o3 (Dec 2024) series, Anthropic's extended-thinking modes, DeepMind's AlphaCode-2 / AlphaProof, and DeepSeek-R1 (Jan 2025) demonstrate the regime empirically. Snell et al. (2024, 'Scaling LLM Test-Time Compute Optimally') and Brown et al. (2024) provide the empirical scaling laws.

Governance implications are direct. (a) Compute thresholds based on training-FLOPs alone (EU AIA 10^2u, US EO 10^2v) understate the deployed capability of inference-scaled models. (b) DeepSeek-R1 demonstrated frontier-tier reasoning at training-compute well below 10^2u FLOPs, weakening the threshold's empirical defensibility. (c) Capability evaluations must specify the inference-compute budget under which the model was tested, since a model can be safe at K=1 and dangerous at K=100. (d) The mitigation surface for inference-time-scaled capabilities is different — restricting access to high-compute deployment APIs is policy-tractable in a way that restricting model-weight distribution is not. The Seoul Declaration + Frontier AI Safety Commitments (May 2024) gesture at this with 'pre-deployment evaluation under realistic conditions,' but no regulator has yet formalised inference-compute-aware thresholds.

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