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When AI Becomes a Complex System: Agents, Emergence, and Real-World Applications

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Extended Abstract

Motivation. Artificial intelligence is moving beyond isolated input–output models toward agentic systems that can pursue goals, plan, use tools, maintain memory, and interact with humans and other AI systems. This development raises a central question: how should we understand AI when its behavior depends not only on a single model, but also on interactions among multiple components over time? We argue that complexity science provides a natural framework [1]. Concepts such as emergence, feedback, self-organization, robustness, and fragility are becoming increasingly relevant as AI systems display properties of complex adaptive systems [1].

Approach and Scope. The talk develops this perspective in three steps. First, it introduces AI agents and distinguishes them from traditional predictive models. Second, it connects agentic AI to core ideas from complexity science, including emergence, nonlinearity, and collective behavior in multi-agent settings [2]. Third, it discusses practical implications in real-world domains, with particular emphasis on autonomous driving. In this setting, an autonomous vehicle is not just a perception-and-control pipeline, but part of a larger ecosystem involving other vehicles, pedestrians, infrastructure, and human conventions [3].

Main Message. The key message is that, as AI becomes more agentic, the relevant unit of analysis shifts from the individual model to the interacting system. This helps explain why standard benchmark evaluations are often insufficient. Agentic AI can give rise to useful emergent behaviors such as coordination, specialization, and adaptive problem solving, but also to undesirable effects such as cascading errors, instability, and brittle dependence on context. In autonomous driving, for example, safety depends not only on perception accuracy, but also on behavior under dense interaction, rare events, and mixed human–machine environments [3].

Conclusion. The talk concludes that complexity science is not only a useful metaphor for modern AI, but an increasingly necessary analytical framework [1]. This suggests that research and governance should move beyond model-centric evaluation toward system-level assessment of interaction effects, resilience, controllability, and emergent behavior.

References

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