

Giorgio Nicoletti

International Center for Theoretical Physics, Trieste, Italy

Friday 14/11/2025, 10 AM, Sala Seminari @ VIMM

Decoding behavior: Inference of decision-making processes with interpretable agent models

Decisions are everywhere. From bacteria to mammals, living systems must continuously make decisions to survive and thrive. Understanding how they do so by processing sensory information from their surroundings is a fundamental problem across several scales. We address this challenge by introducing a method to infer decision processes directly from behavioral data, without requiring any prior knowledge about the agent or the environment. We use as minimal agent models Finite State Controllers (FSCs), which are defined by a discrete set of internal agent states, a policy that maps these states into decisions, and an update of the internal states that processes sensory information and performs computations. Crucially, FSCs with a small number of internal states can unveil the computational structure underlying diverse decision-making behaviors. We test our framework by inferring FSCs from experimental data of rats performing evidence accumulation tasks and of mice making decisions under uncertainty, in changing environments. In both cases, few internal states suffice to accurately reproduce behavior. Thanks to their discrete nature, FSCs provide transparent and interpretable descriptions of the computational process at work, revealing the spontaneous emergence of buffer states and states performing switch detection. Our results demonstrate that our method can decode the essential structure of biological decision-making from behavioral trajectories alone, providing a broadly applicable framework for understanding how agents make decisions in complex environments.



P A D O V A
neuroscience
C E N T E R