Flexible Physical Problem Solving with Strategy Acquisition and Composition

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Abstract

Humans exhibit a remarkable ability to acquire, generalize, and compose strategies for object manipulation, yet the underlying mechanisms of this flexible strategy learning and reuse remain poorly understood. In this paper, we extend the Virtual Tool Game (Allen, Smith, & Tenenbaum, 2020), where humans solve complex physical puzzles in just a few attempts. Through two behavioral experiments, we show that humans acquire abstract strategy representations and can flexibly chain multiple strategies for novel tasks in both forward and backward directions. To formalize this process computationally, we introduce a probabilistic framework that models physical events, actions, and high-level manipulation strategies. Our approach represents strategies as amortized sequences of physical events and integrates them into a bi-level search mechanism that combines simulation and planning. These findings advance our understanding of human physical reasoning and contribute to the development of AI systems with human-like physical problem-solving capabilities.

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