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Title: Challenges and Opportunities in Intelligent Dynamics

Abstract: As if making good decisions isn't hard enough, many important problems require good *sequences* of decisions. A domestic robot may need to not just grasp a cup, but in such a way that water doesn't spill when it hands it to a human. If the robot uses a priority queue to perform important tasks first, it must identify each task and insert it into the queue before it can later retrieve the task and perform it. When it comes to learning to control a robot or to synthesize a computer program, the sequential nature of decision making has far-reaching implications for all components of learning, including data, model, and optimizer: How can we optimally collect data through exploration of the huge decision-sequence space? How can we leverage temporal structure of the control model to learn it more efficiently? And how can we analyze and improve the dynamics of the optimization process itself?

In the Intelligent Dynamics Lab, we tackle these questions by developing theory, inventing algorithms, building systems — and applying these to real-world problems in robotics and program synthesis. In theory projects, we use mathematical tools from reinforcement learning, optimal control, and information theory, to answer questions such as how to identify agency in video, and how to optimize under changing uncertainty. In algorithms projects, we come up with clever ways to teach robots and synthesize programs, such as by integrating multiple data sources, and by jointly learning multiple tasks. We put it all to practical use in two systems projects: SkillHub is a cloud service for multi-task learning, where robots can share skills to avoid learning each task from scratch; and Atlas is a program synthesis paradigm that lets developers look up API usage by input–output examples.