Research Abstract

Current robot planning approaches, particularly in Task and Motion Planning (TAMP), often operate myopically. They solve assigned tasks in isolation, failing to consider the long-term consequences of their actions on future, unassigned tasks or other agents in shared environments. This limitation leads to unintended negative side effects; for instance, a robot might clear a table by moving objects to a nearby desk, successfully completing the immediate task but cluttering the workspace and increasing the cost of subsequent tasks, such as washing the dishes. As robots are deployed for continuous operation in persistent environments, this myopic behavior can degrade the environment's state, making unassigned future objectives more difficult.

My research introduces *anticipatory planning*, a framework designed to overcome this myopia by enabling robots to reason about the impact of their actions on unknown future tasks. The core challenge is that future tasks are not known in advance. To address this, my work asserts that a distribution over probable future tasks is inherent to any given environment. By learning to estimate the expected future cost associated with future tasks–a metric we define as the *anticipatory planning cost*–the robot can guide its planning process to making anticipatory decisions even in the absence of missing information of future tasks. This approach integrates learning-augmented planning, allowing the robot to transfer knowledge from an offline training phase to deployment. This enables the robot to make forward-thinking decisions that minimize negative side effects and encourage environment organization, transforming it from a mere reactive machine into a proactive partner.

Significance of My Research

This research addresses a fundamental limitation in the field of robot task and motion planning. While existing TAMP solvers are highly effective at generating plans for complex, well-defined tasks, their performance degrades for the long-lived, continuous operation expected of assistive and service robots. My work pushes the boundary of robot planning from isolated problem-solving to life-long autonomy. By equipping robots with the ability to anticipate and mitigate the downstream effects of their actions, this research provides a crucial step towards developing intelligent systems that can act as considerate and effective collaborators, maintaining order and efficiency in shared spaces over extended periods.

The implications of anticipatory planning are significant and span numerous domains where proactive, intelligent decision-making is essential. In warehouse automation, an anticipatory robot could strategically place frequently accessed items in more accessible locations, helping the workflow for future retrieval tasks it has not yet been assigned. In assisted living, a service robot could preemptively arrange furniture to ensure clear pathways or prepare medications before they are explicitly requested, enhancing safety and care. In retail, robots could predict inventory needs based on customer trends and proactively restock shelves. Ultimately, this research contributes to the development of more capable and seamlessly integrated robot assistants that do not just complete tasks, but actively improve the environments in which they operate.