AssemblyComplete: 3D Combinatorial Construction With Deep Reinforcement Learning

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A critical goal in robotics and autonomy is to teach robots to adapt to real-world collaborative tasks, particularly in automatic assembly. The ability of a robot to understand the original intent of an incomplete assembly and complete missing features without human instruction is valuable but challenging. This paper introduces 3D combinatorial assembly completion, which is demonstrated using combinatorial unit primitives (i.e., Lego bricks). Combinatorial assembly is challenging due to the possible assembly combinations and complex physical constraints (e.g., no brick collisions, structure stability, inventory constraints, etc.). To address these challenges, we propose a two-part deep reinforcement learning (DRL) framework that tackles teaching the robot to understand the objective of an incomplete assembly and learning a construction policy to complete the assembly. The robot queries a stable object library to facilitate assembly inference and guide learning. In addition to the robot policy, an action mask is developed to rule out invalid actions that violate physical constraints for object-oriented construction. We demonstrate the proposed framework's feasibility and robustness in a variety of assembly scenarios in which the robot satisfies real-life assembly with respect to both solution and runtime quality. Furthermore, results demonstrate that the proposed framework effectively infers and assembles incomplete structures for unseen and unique object types.

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