ASCEND: Autonomous Structure Construction With Novel Agent Swarms

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Across the world, hundreds of millions of people are affected by a global inability to meet construction demands. In particular, widespread infrastructure inadequacy that will reach $100 trillion by 2040 has had devastating impacts on health outcomes, economic productivity, and quality of life. Unfortunately, despite the growing need for infrastructure and construction solvency, existing approaches fail to address the root of the problem: insufficient flexibility and efficiency. The researcher devised a solution to this problem by developing ASCEND, an autonomous structure construction framework utilizing agent swarms. ASCEND employs a reinforcement learning model trained in a high-fidelity simulation environment to achieve task-level coordination between multiple unmanned aerial vehicle (UAV) agents in an arbitrary workspace. Agents were trained with an on-policy, centralized critic-decentralized actor approach. Furthermore, computer vision algorithms, including fiducial markers, were trained with real-world data to guide agents in their final approach. Each physical agent is a custom-designed quadcopter with a 3D printed end effector to manipulate structural components. Results collected during ASCEND's training revealed expected reward and policy/value loss curves. The structure completion accuracy in-simulation was over 96% and aligned with real-world testing, affirming the simulation fidelity. Scalability and robustness testing across multiple environments indicated minimal variability in structure completion accuracy and rate, demonstrating the framework's efficiency under a variety of conditions. All initial criteria and constraints were met by the final agent-swarm prototype, establishing ASCEND's potential to remedy global construction inadequacy.

Awards Won: