ABSTRACT

As wildfires become increasingly destructive and unpredictable, efficient and continuous data collection is critical for understanding and mitigating their impact. While satellites and both manned and unmanned aerial vehicle (UAV) systems provide valuable visual and spatio-temporal data, they remain limited in their ability to capture the full lifecycle of wildfire events, which can span weeks to months and cover vast geographic areas.

To address this challenge, we propose a coordinated team of autonomous UAVs that collaboratively monitor wildfire environments over extended periods. By taking turns for recharging and maintenance, the system maintains persistent coverage and enables comprehensive observation of wildfire dynamics. Additionally, this approach captures critical spatio-temporal information often missed by traditional methods, including localized wind velocity, temperature, humidity, and other environmental factors influencing fire behavior.

Our approach leverages multi-agent deep reinforcement learning (MARL) to enable cooperative behavior among UAVs toward the shared objective of wildfire tracking and coverage. Through coordinated decision-making, the system decomposes complex monitoring objectives into parallel tasks, improving efficiency and scalability. This cooperation enhances information sharing, increases confidence in collected data, optimizes task allocation, maintains network connectivity, and ensures collision avoidance.

To evaluate our approach, we developed a simulation environment using ROS2-Gazebo and implemented a scaled-down indoor experimental setup with multiple autonomous UAVs. This work represents an initial step toward real-world deployment, where UAV teams can be used in field scenarios such as prescribed burns to collect large-scale visual and spatio-temporal datasets. Such data is essential for enabling data-driven wildfire analysis and improving predictive modeling capabilities.

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