Realistic Simulation for a Distributed & Coordinated Multi-Drone System

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Introduction

- Natural disasters often create environments which are dangerous for human responders. As UAV technology advances, drones can autonomously search for survivors and deliver supplies, boosting the speed and impact of rescue efforts.
- While drones excel in autonomy, coordinating multiple drones remains challenging. In emergencies like floods or forest fires, manual centralized control is often impractical due to delays, unstable networks, or large coverage areas. Drones must autonomously share positions, divide tasks, communicate detections, and adapt roles to avoid overlap, missed targets, or critical delays

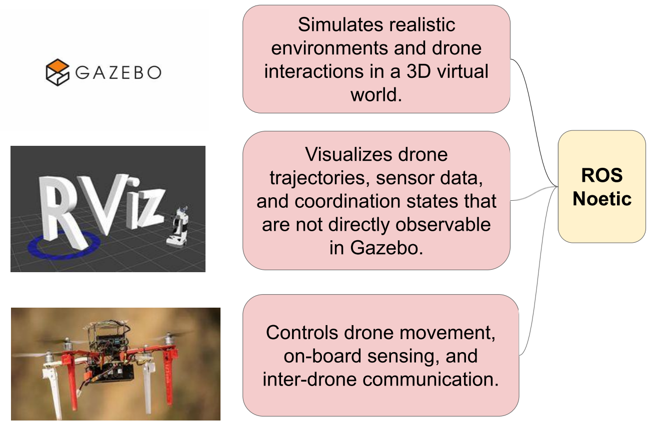
Objectives

- Develop a realistic simulator for multi-drone systems that supports distributed autonomy, real-time inter-drone communication and coordination, and live sensing data visualization.
- Design distributed algorithms that enable coordinated target searching with the multi-drone system.

Fig 1a.Multi robotic drone system

Fig 1b. Custom built drones from SmartNet Lab

System Overview



Fly4Future Drone

Coordinated Target Searching

- **Objective:** Enable a team of autonomous drones to collaboratively search for targets through distributed coordination, communication, and dynamic task allocation.

a) Set up a stable wireless network for UAV coordination.

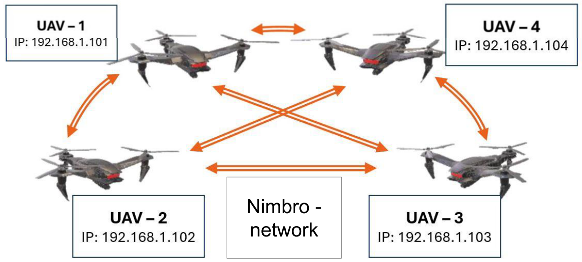


Fig 2. Wireless Nimbro network in UAVs for coordination and communication

b) Distributed Search Algorithm for Rapid Area Coverage

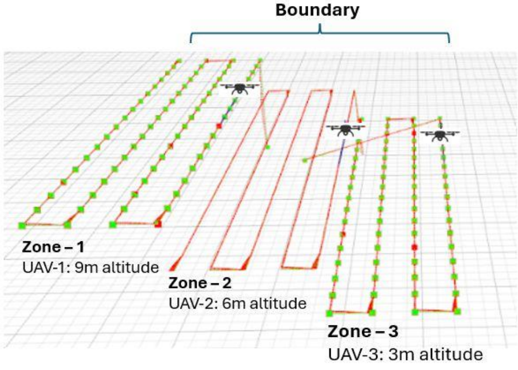


Fig 3. Coordinated Target Search via Zone-Based Distributed Path Planning

c) Target Pose Estimation using computer vision

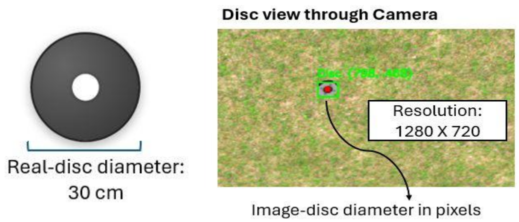
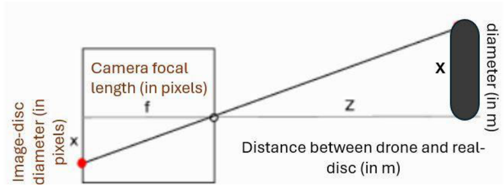


Fig 4. Pose estimation using computer vision and pinhole camera principle



$$\text{Distance between Drone and Disc} = \frac{\text{real disc diameter in meters } X \text{ focal length of camera in pixels}}{\text{image disc diameter in pixels}}$$

Results

- **Actual vs Calculated Disc Coordinates**

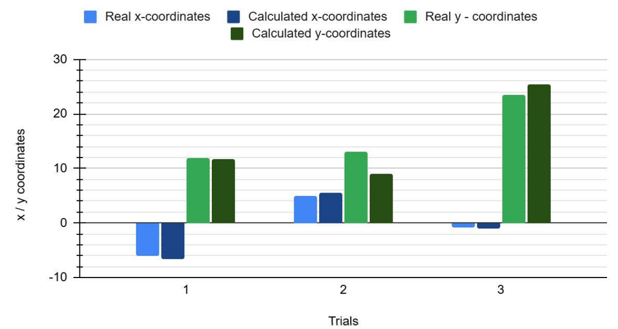


Fig 5. Clustered Bar Graph for comparison of actual vs calculated disc coordinates

- **Final Formation of Drones around the target in simulation**

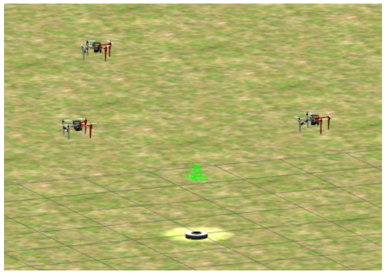


Fig 6: The drones converge to the target after detection in the form of a circle

- Following validation, these simulations can be tested on our custom-engineered real-time drones built in our lab.

References

[1] "Image Processing and Computer Vision" https://staff.fnwi.uva.nl/r.vandenboomgaard/IPCV20162017/LectureNotes/CV/PinholeCamera/PinholeCamera.html.

[2] "UVDAR system: Drone Doc," Fly4Future, https://documentation.fly4future.com/docs/simulation/uvdar.