IEEE International Conference on Robotics and Automation Workshop on Resilient Robot Teams: Composing, Acting, and Learning 2019

An Approximation Algorithm for Distributed Resilient Submodular Maximization

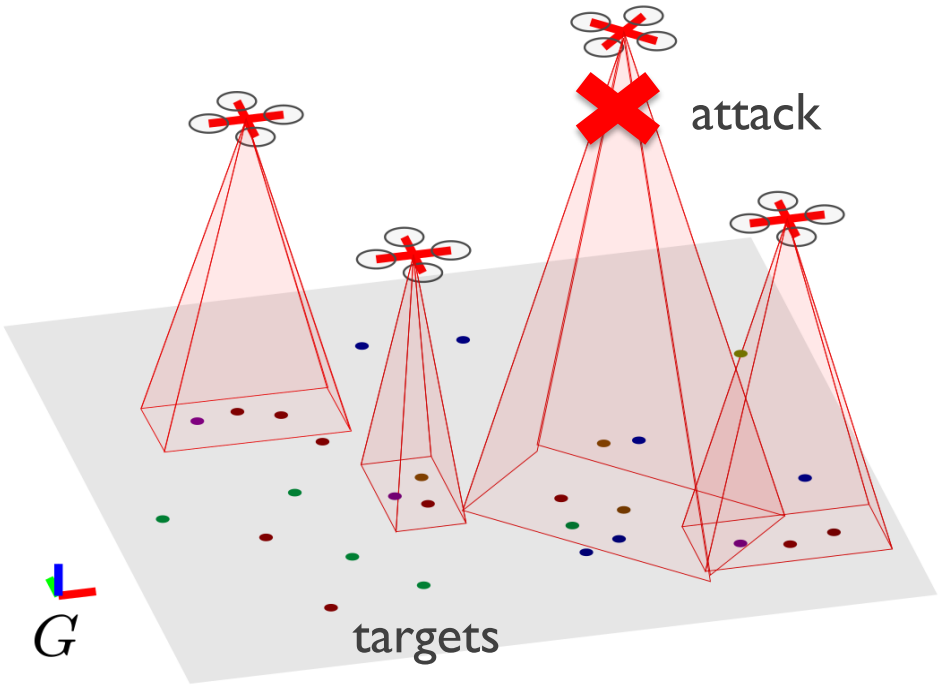
Lifeng Zhou and Pratap Tokekar

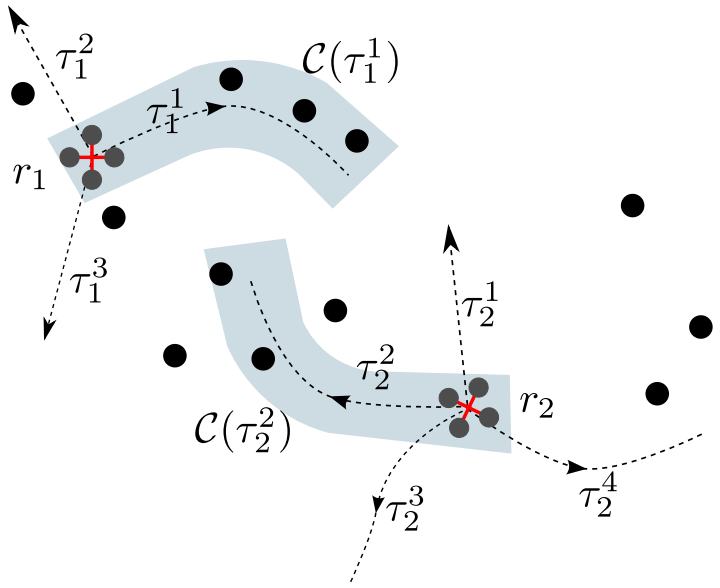
RAAS Lab

VIRGINIA TECH

Adversarial Attacks

- Multiple robots collaboratively track ground targets
- An adversary attacks a number of robots to block and compromise their tracking sensors





Submodular Maximization

- Standard version

$$\max\ f(\mathcal{S}),\ \text{s.t. } \mathcal{S} \subseteq \mathcal{X}$$

  - NP-complete
  - The standard greedy algorithm

- Resilient version

$$\max_{\mathcal{S}\subseteq\mathcal{X}}\ \min_{\mathcal{A}\subseteq\mathcal{S}}\ f(\mathcal{S}\setminus\mathcal{A})$$

$$s.t.\ \ |\mathcal{A}| = \alpha \leq N$$

  - N robots, α attacks
  - Worst case attack set, $\mathcal{A}$

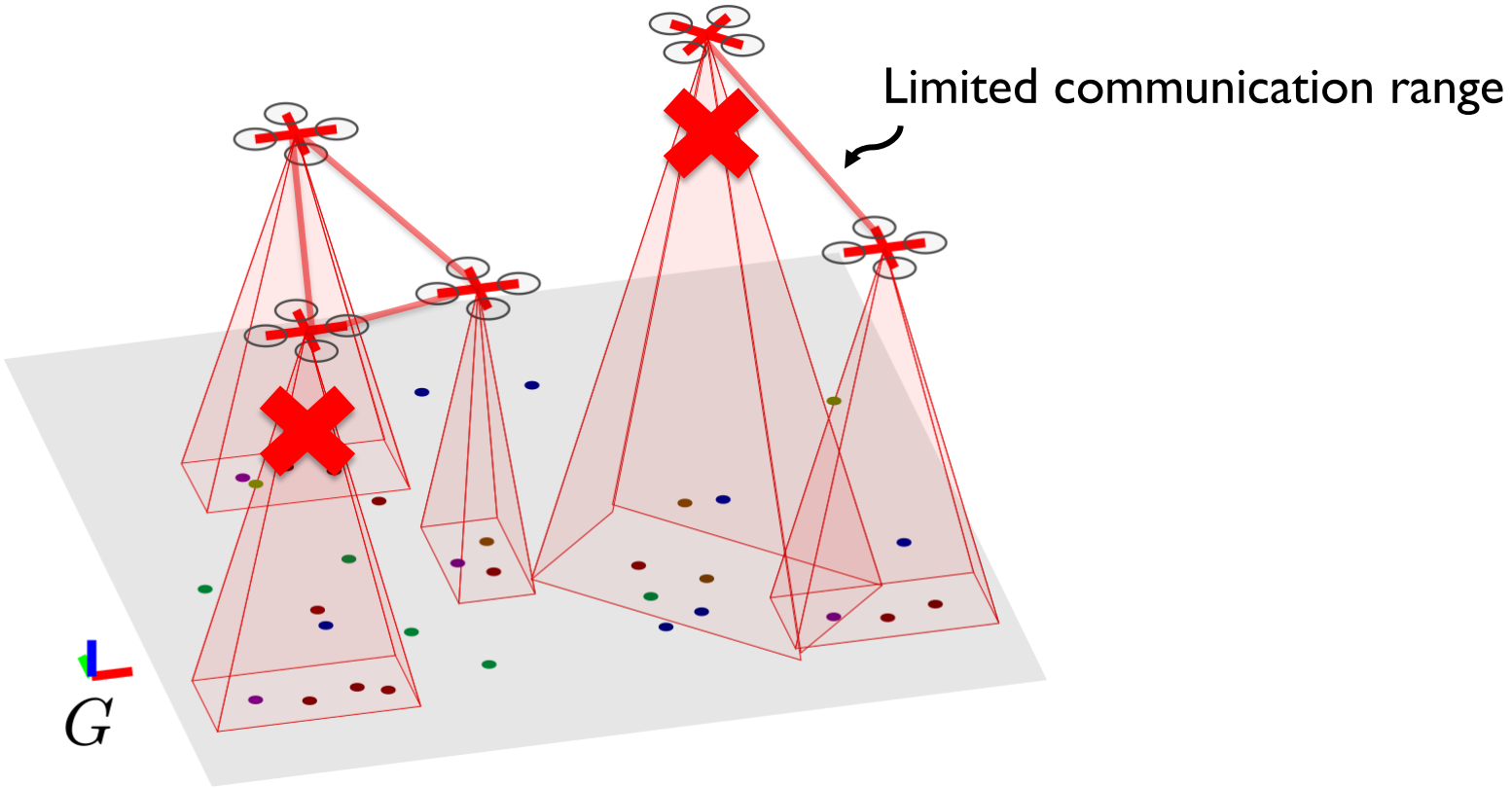
Centralized Resilient Target Tracking

- All robots can communicate with each other
- A centralized resilient algorithm
- Performance:
  - A constant-factor approximation of the optimal
  - As fast as the standard greedy algorithm [Fisher et al., PC '1978]

L. Zhou, V. Tzoumas, G. J. Pappas, and P. Tokekar. *ICRA+ RA-L '19*
Resilient Active Target Tracking With Multiple Robots
MoC1-23 Interactive Session, 220
Path Planning for Multi-Robot Systems II - 1.3.23

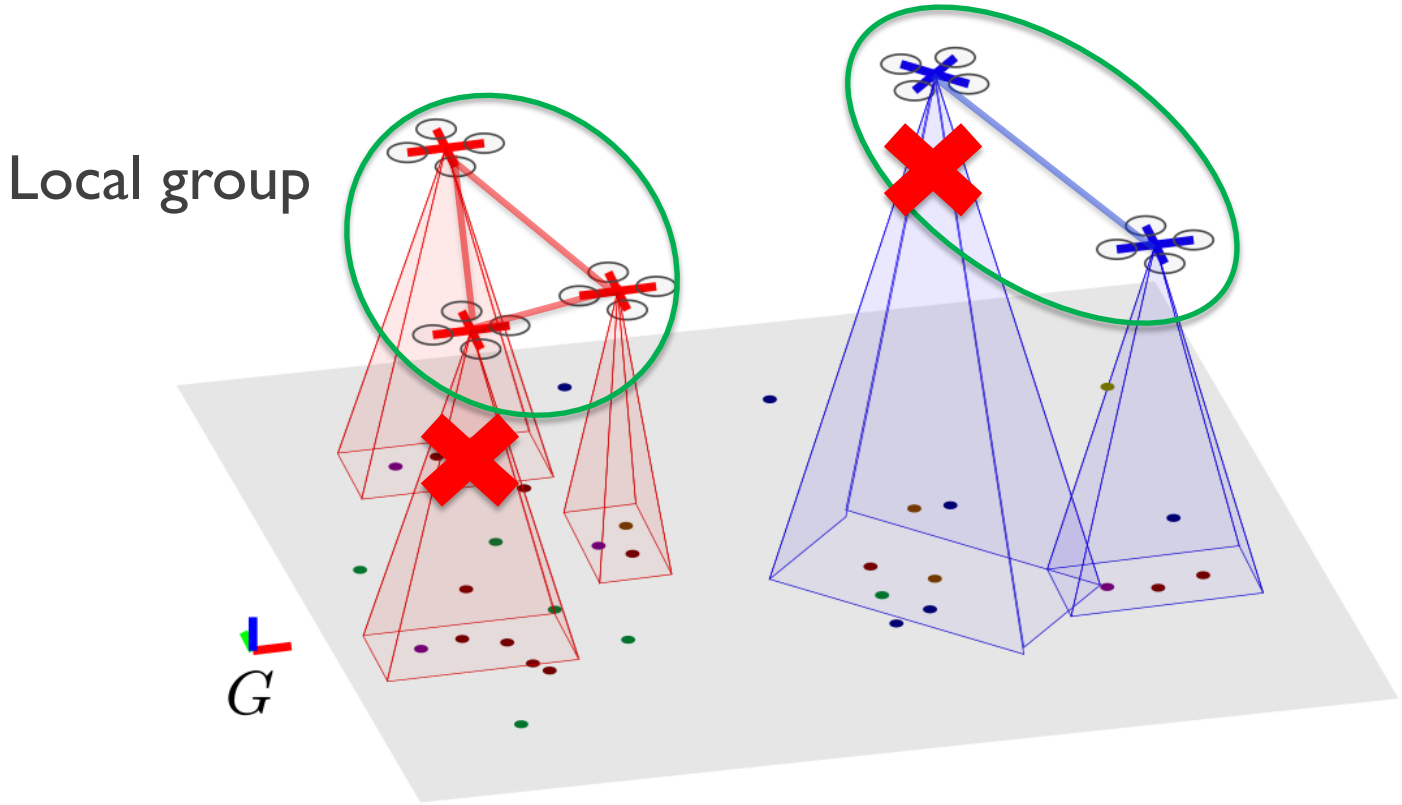
Decentralized Target Tracking

- An adversary attacks a number of robots
- Robots have a limited communication range



Distributed Resilient Algorithm

- The robots form local groups, cliques
- All cliques perform a resilient algorithm in parallel



Performance Analysis

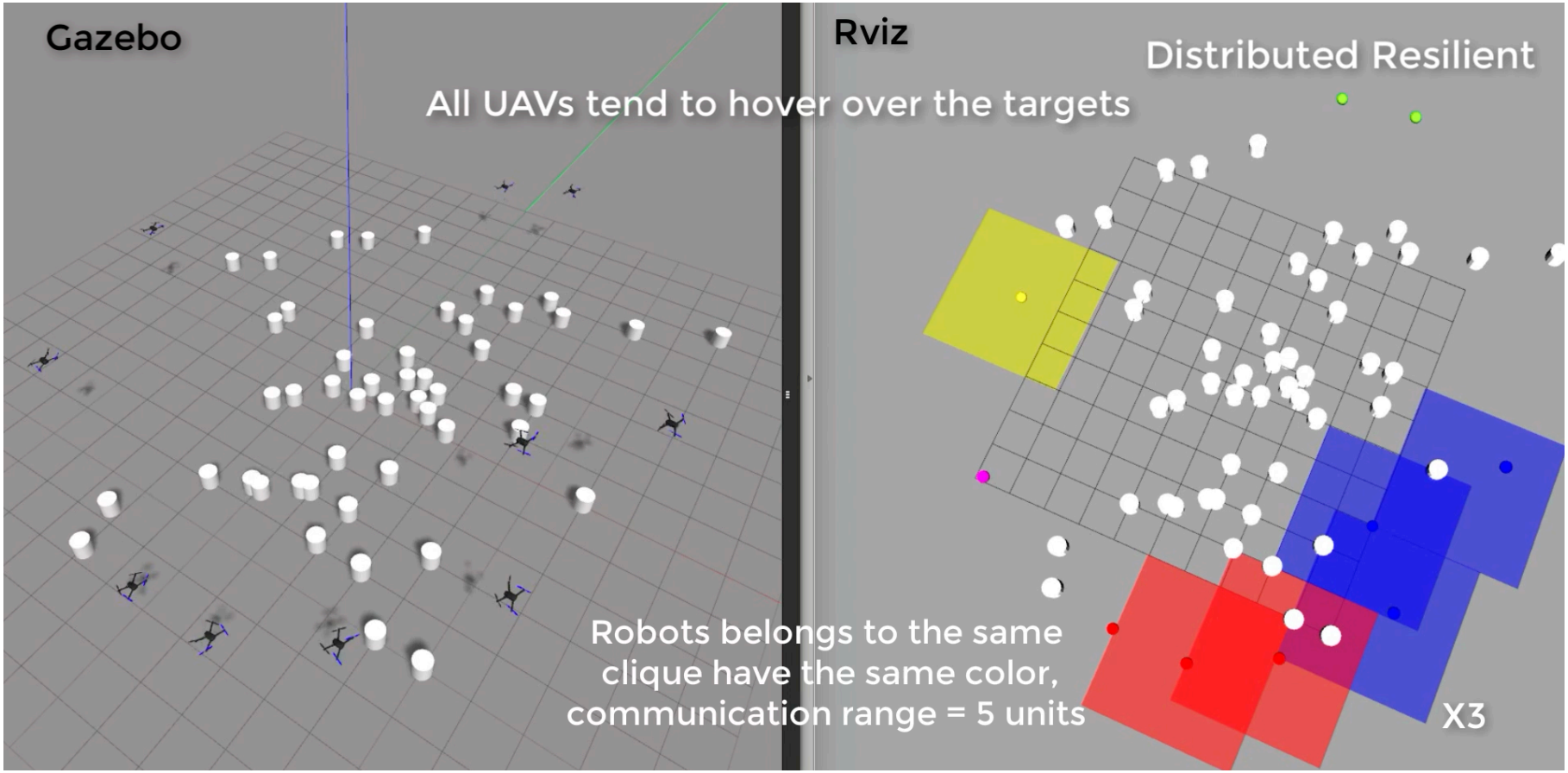
- Gives a constant-factor approximation of the optimal

$$\frac{f(\mathcal{S} \setminus \mathcal{A}^\star(\mathcal{S}))}{f^\star} \geq \max\left[\frac{1-k_f}{1+k_f}, \frac{1}{(\alpha+1)\mathcal{K}(\mathcal{G}_2)\omega(\mathcal{G}_2)}, \frac{1}{(N-\alpha)\mathcal{K}(\mathcal{G}_2)\omega(\mathcal{G}_2)}\right]$$

- Depends on the clique number and the number of cliques on the communication graph
- Runs faster than centralized resilient algorithm

[Zhou et al., RA-L '19]

Thanks for listening!



lfzhou@vt.edu
www.raas.ece.vt.edu

RAAS Lab

VIRGINIA TECH