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Scientific abstract – ***How to defend a city from drone swarm attack: A Security Games approach***

Algorithmic research on Stackelberg Security Games (SSGs) in the multi-agent community has had a high real-world impact, focusing mainly on Stackelberg equilibrium in normal-form games, involving defenders committing to mixed strategies, attackers responding, and utilities being determined. However, the rise of drone threats to large cities introduces novel challenges that the SSG community has yet to address comprehensively.

We propose studying Stackelberg games for sequential, extensive-form games motivated by the need to defend against swarm drone attacks. The unique challenges include defending against sequential attacks from multiple drones, accounting for battery constraints and limited payload, considering diverse unit types, handling information availability variations, and navigating the city's structure, allowing drones to move in continuous spaces.

Two frameworks are proposed to address these challenges: Sequential Stackelberg Security Games over a Graph (SSGG) and Sequential Stackelberg Security Differential Games (SSDG). In the first framework, targets are represented as nodes on a graph, with defenders strategically deploying static units and drones. The second framework, SSDG Games, involves continuous movements in continuous time. It extends the study to a two-dimensional plane, addressing the movement of attacker and defender units building on top of the pursuit-evasion game model. The objective in both frameworks is for defenders to eliminate attackers who repeatedly try to attack targets while accounting for battery constraints and diverse drone capabilities.

Due to the complexity and NP-hard nature of the problems, we propose to develop approximation and heuristic solutions when necessary, evaluating them by formal analysis and extensive simulation studies. We will focus on hierarchical approaches that first divide the city into "neighborhoods" and decompose the problem into a limited number of unit subgames, aiming at individual unit subgames. The limited battery and payload that characterize drones will also be used in the development of heuristics and approximation solutions. For the SSDG Games that enable continuous movements in continuous time, we will integrate methods developed for solving differential games with techniques for identifying mixed strategies that have been studied extensively by the multi-agent security games community.