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CONTROL OF ANTAGONISTIC SWARM DYNAMICS VIA LYAPUNOV'S METHOD

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ABSTRACT

We consider hostile conflicts between two multi-agent swarms. First, we investigate the complex nature of a single pursuer attempting to intercept a single evader (1P-1E), and establish some rudimentary rules of engagement. We elaborate on the stability repercussions of these rules. Second, we extend the modelling and stability analysis to multi-agent swarms with conflicting interests. The present document considers only swarms with equal membership strengths for simplicity. This effort is based on a set of suggested momenta deployed on individual agents. Because pursuers and evaders differ in the influences that they exert on one another, we emphasize asymmetry in momenta between the two types of swarm members. The proposed centralized control law evolves from a Lyapunov concept. Swarm interactions are modelled in two phases: the *approach phase* during which the two swarms act like individuals in the 1P-1E interaction; and the *individual pursuit phase* where each pursuer is assigned to an evader.

Key Words: Stability of swarm dynamics, Lyapunov stability, conflict, asymmetric momenta, antagonistic swarms.

I. INTRODUCTION

This study addresses the modeling, analysis, and control of multi-agent swarm dynamics. When each agent influences multiple other agents, the emergent dynamics can become quite complicated. Most earlier investigations that focus on the stability of swarm dynamics consider homogenous swarms, i.e. those composed of like members [1–8]. The structure of attraction/repulsion momenta among the members is modeled under different assumptions, varying from spatial to group approaches, from individual based (Lagrangian) to continuum (Eulerian) perspectives. Here we extend this analysis to multi-agent systems containing two different types of agents with sharply conflicting goals. In particular, we consider a swarm of pursuers chasing multiple evaders, a task in which cooperative behavior can be favored (e.g. [9–11]).

Biologically inspired models of swarm behavior are often based on distance-based functions of attraction and repulsion between individuals (e.g. [12, 13]). When deployed across the members of a group, these forces permit cohesive behavior despite substantial individual variation in movement. Furthermore, such forces can permit coordinated movement among

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