Nonlinear Dynamics and Systems Theory, 25 (3) (2025) 315-337



## Formation Flight of UAVs for Search and Detection Missions by Tracking Time-Variable Trajectories

Rolando Díaz-Castillo <sup>1</sup>, Rosa Martha Lopéz-Gutiérre<br/>z $^{1\ast},$ Juan José Cetina-Denis  $^2$  and César Cruz-Hern<br/>ández  $^2$ 

<sup>1</sup> Engineering, Architecture and Design Faculty, Baja California Autonomous University (UABC), Ensenada 22860, BC, México.

<sup>2</sup> Electronics and Telecommunication Department, Scientific Research and Advanced Studies Center of Ensenada (CICESE), Ensenada 22860, BC, México.

Received: November 6, 2024; Revised: June 7, 2025

**Abstract:** In this paper, the formation problem of multiple unmanned aerial vehicles (UAVs) is addressed. In particular, the formation of UAVs is achieved by using complex systems theory and backstepping nonlinear control. We apply the obtained formation of multiple UAVs to search for and detect a target of interest within an exploration area. In addition, a coverage study of the formation of UAVs for search and detection by tracking time-variable trajectories is reported.

**Keywords:** complex systems; formation control; backstepping control; multiple UAVs; search mission.

Mathematics Subject Classification (2020): 70K42, 93-08, 93-16.

## 1 Introduction

From the formation of some kinds of birds to extend their flight time, to the grouping of fish to avoid attacks of predators, different groups of animals often associate naturally to achieve a common goal or benefit, which they individually could not achieve, and therefore could not survive [6], [18], [19].

The exchange of information due to the interactions between the members of these groups gives rise to a set of collective behaviors that are different from an isolated individual behavior. It is called emergent collective behavior [17], [21].

<sup>\*</sup> Corresponding author: mailto:roslopez@uabc.edu.mx

<sup>© 2025</sup> InforMath Publishing Group/1562-8353 (print)/1813-7385 (online)/http://e-ndst.kiev.ua315