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ON THE ROTATIONAL CUCKER-SMALE MODEL: OPTIMAL FORMATION CONFIGURATION AND ADAPTIVE GAINS DESIGN

Abstract

Collective behaviors of flock of animals have been used in many different fields to design control strategies for systems composed of multiple agents. Among others, the translational model proposed by F. Cucker and S. Smale offers several insights on the dynamics of these systems.

In particular, in the context of attitude dynamics, the distributed structure of a formation can be exploited to lead it to an emergent state, where the satellites have the same angular momentum. Furthermore, similarly to the Cucker-Smale model, in a previous work we have shown that, by appropriately scaling the gains of the control with respect to a convenient relative state measure, significant improvements on the synchronization time (with respect to standard PD-like control laws) can be obtained, especially for very large formations.

Following these results, in this paper we present strategies to optimize the aforementioned law, both in terms of synchronization time and computational load. To this purpose, the following research directions are considered.

First, as a result of previous simulations, we know that the number and distribution of links in the communication graph play a fundamental role in the performance of the control. Thus, given a certain graph and a set of initial conditions, we investigate what is the optimal arrangement (in terms of synchronization time) of those conditions in the given graph. Furthermore, we study the relation of this optimal arrangement with the dimension of the formation and particular features of the graph.

Secondly, several metrics have been proposed in the literature to measure distances between three dimensional rotations. In the present work we explore the impact of these metrics on the control performance when they are employed in the adaptive gains design. As stated before, their impact is evaluated as a function of computational load and synchronization time.

Finally, we analyze the robustness of our control when subject to limitations on the torque (in particular, when a magnitude threshold is present). As for the previous points, this analysis will be conducted mainly through appropriate numerical tools.