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A DISTRIBUTED ATTITUDE CONTROL LAW FOR FORMATION FLYING BASED ON THE CUCKER-SMALE MODEL

Abstract

Common control strategies, based on tracking approaches at the single agent level, may not be the best choice for controlling attitude in the context of a formation, especially when this may contain many simple spacecrafts. In this paper we introduce an autonomous attitude control strategy suitable for formations with a large number of agents. The basic idea of the proposed methodology is to extend to the attitude dynamics setting a control law, first introduced by F. Cucker and S. Smale to describe collective behaviours in flocks of animals, which has been widely used (biology, sociology and robotics just to mention a few fields) to control the translational dynamic of systems composed of multiple agents. The procedure takes advantage of the distributed structure of a formation to lead it to an emergent state, that is a state where the satellites have the same angular momentum, both in magnitude and direction. The value of this target vector can be customized through the introduction of a hierarchical structure in the formation, where the leader determines the final angular momentum, while the hierarchy allows for a drastical reduction of computational load for each satellite. Several are the advantages of this control. Among others, it is worth mentioning that the convergence, for a certain set of parameters, is unconditional, that is it does not depend on the initial conditions of the spacecrafts. Besides making the control quite stable, this allows for its implementation to be done automatically by the agents, without the need of external intervention. Furthermore, it should be noted that, while this paper is focused on attitude dynamics, the results that we present here can be easily reproduced in the context of translational dynamics, specifically when it is desirable for the formation to rotate around a certain point (like an asteroid, for example). Numerical simulations are conducted to show that the control offers very good performances when applied under the presence of low-magnitude vector fields such as the attitude one (which falls in this category due to the generally limited spin rates of spacecrafts). Furthermore, additional experiments are conducted to study how the performance of the control scale with the dimension of the formation and how it behaves under the presence of different vector fields (which will be selected according to the possible applications of formation flying). Finally, for every set of simulations, the impact of the different parameters involved will be analyzed.