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A connectivity preserving rendezvous for unicycle agents with heterogenous input disturbances

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Abstract

This paper studies the rendezvous strategy for a group of unicycle systems with connectivity preservation and collision avoidance. Based on the method of potential functions, a novel distributed control algorithm is proposed for all unicycles. By tuning the design parameters, the unicycles finally aggregate so that the average of the distances is bounded by a pre-specified positive number. It is proved that the connectivity of a minimum spanning tree in the initial topology is guaranteed. The result is then extended to multiple unicycles with heterogenous input disturbances. Potential function is further modified to handle the disturbances. Illustrative example is presented to show the improvements and effectiveness of the proposed controller.

1. Introduction

Nowadays, extensive research attention has been paid on the study of multi-agent systems for their board applications in various fields, such as networks [1], robots [2–4], unmanned air vehicles [5,6], and so on. One of the most important control objectives is to construct

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an appropriate control algorithm such that the states of all agents converge to a common constant. A large number of related literatures have emerged, see [7–13], and the references therein. Nevertheless, such control objective is unrealistic and should be modified in practical applications.

The flocking problem with connectivity preservation is aiming to achieve consensus while maintaining the connectivity of the graph, which guarantees the solvability of the problem during the evolution. [14] considered the rendezvous of multiple mobile agents, where the connectivity of the graph was maintained with connected initial network. The bounded coordinated control problem for multi-agent systems with limited communication ranges was studied in [15]; the connectivity of the agent group was preserved by using the explicitly defined virtual neighbors. In [16], the free-flocking and constrained flocking with obstacle avoidance were both considered; a systematic method was presented for construction of collective potential functions. [17] considered the connectivity preserving formation stabilization for single-integrator multi-agent systems with obstacle avoidance. Based on a navigation function candidate, a class of decentralized control algorithm was addressed. Note that collision avoidance between all agents is also very important in real applications. [18] further investigated the flocking problem for multiple double integrator systems with connectivity preservation and collision avoidance, where external disturbances were considered in the dynamic of each agent. Subsequently, [19] studied the collision-free formation control for multiple nonholonomic-wheeled mobile robots with connectivity preservation.

Up to now, the flocking the problem for multi-agent systems with connectivity preservation and collision avoidance have been studied for many years. Nevertheless, few results have evaluated the relative distances among all agents with connectivity preservation and collision avoidance as that in [20]. Note that in [20], the bounded distributed aggregation for single-integrator multi-agent systems with connectivity preservation and collision avoidance has been investigated. However, the performance of the controller is easily affected by the pre-specified number, which is employed to evaluate the average of the relative distances. Motivated by this, we consider the flocking problem with connectivity reservation and collision avoidance by proposing a novel distributed controller. The contributions of this paper are threefold. First, by applying the modified potential function presented in this paper, a novel distributed control algorithm with improved performance is designed to guarantee the connectivity preservation and collision avoidance. By using the constructed controller, the average of the relative distances between all unicycles is bounded by an adjustable positive number, which is different from the results in [18,19]. Second, the controller in this paper only guarantees the connectivity of a minimum spanning tree in the initial graph, which has achieved lower communication costs. Finally, the proposed controller is further used to discuss flocking problem for multiple unicycles with heterogenous input disturbances.

This paper is organized as follows. In Section 2, some preliminaries are presented and the problem is formulated. Section 3 addresses the controller design and stability analysis. In section 4, simulation is presented to show the improvement and effectiveness of the controller.

2. Preliminaries and problem formulation

2.1. Preliminaries

The following symbols will be given in the first place : $R^{N\times N}$ and R^N denote the sets of $N\times N$-dimensional and N-dimensional Euclidean spaces, respectively. R^+ represents the set