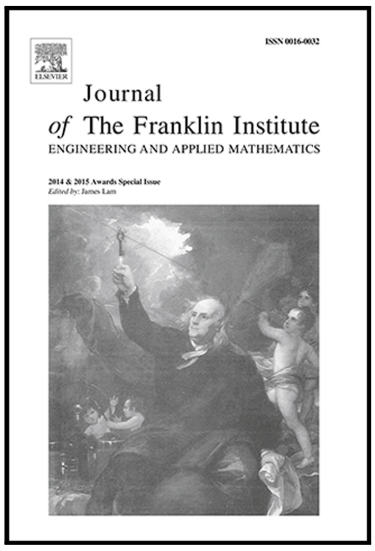

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Stabilization of Collective Formations with Speed and Controller Gain Heterogeneity and Saturation

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Abstract

This paper studies collective formations of multi-agent systems, modeled with unicycle dynamics, while admitting heterogeneity in both controller gains and speeds of the agents along with saturation on the controller outputs. This addresses a practical scenario where the speeds are usually nonidentical and the controller gains may vary due to imperfect implementation. The paper analyzes the effect of both heterogeneous controller gains and speeds simultaneously on the collective formations obtained by optimizing the average linear momentum of the group of agents. A detailed analysis of the two-agent system is given in the paper and some results on the locus of the collective centroid with varying controller gains are obtained. Effect of saturation is also studied for two cases when the controller gains are bounded and when the control efforts are bounded. Simulation examples are given to illustrate the theoretical findings.

Keywords: Heterogeneity, Cooperative control, Collective formation, Nonlinear systems.

1. Introduction

Recent challenges in the field of distributed and cooperative control include the analysis and controller synthesis for heterogeneous multi-agent systems. Heterogeneity in multi-agent system is of practical relevance as, in reality, agents in a group will never be perfectly identical due to different physical parameters or operating conditions. Therefore, the consideration of heterogeneity in multi-agent systems is quite natural and is an attempt to match reality. In certain applications, heterogeneity in multi-agent systems may also arise due to the mission requirement where a team of agents, with each agent having individual kinematic and functional abilities, is trying to achieve a common goal or multiple consecutive tasks cooperatively. Therefore, compared with homogeneous systems, the study of collective behavior of heterogeneous multi-agent systems is more practical. It is also more challenging as the standard results of the homogeneous system, which it generalizes, no longer apply directly.

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