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# DISTRIBUTED $\mathcal{H}_\infty$ COOPERATIVE CONTROL OF MULTIPLE AGENTS TO MAKE FORMATIONS

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Abstract. *Robustness of a multi-agent cooperation system is of particular importance for practical applications, and is a challenging field that has not been explored on a satisfactory level. In this paper, a novel complete distributed control architecture with robustness incorporated for a multi-agent cooperation system is proposed. This architecture contains a middle layer, which is also termed the information flow layer with second or higher ordered information flow filters that determine the dynamical performance of the overall system, and a base layer, which is termed the stabilization layer with distributed controllers that are scalable and are robust to external disturbances. The proposed framework is a generalized one that provides one with maximal flexibility for the synthesis of multi-agent cooperation systems. Moreover, the introduction of distributed controllers significantly broadens the applications of existing multi-agent formation systems under poor environment. By introducing the change of variable approach into the synthesis of distributed controllers, we derive an analytical method that is complementary to existing results. This complete distributed framework is experimentally implemented and validated on a three-robot formation system and experimental results show the validity and advantages of this complete architecture in aspects of robustness and flexibility.*
**Keywords:** Multi-agent cooperation, Distributed control, Formation stability, Algebraic graph theory

1. **Introduction.** The study of distributed control strategies for multi-agent cooperation systems has emerged as a challenging new research area, and has attracted a lot of scholars in recent years due to its broad range of applications, e.g., [1, 2, 3, 4]. In multi-agent systems, various kinds of agents such as sensor nodes, spaceships and wheeled vehicles, which act in an autonomous and flexible manner, exist at the same time and carry out cooperative tasks that are beyond the capability of single ones. Examples of multi-agent cooperation systems include satellites flying together in formation [5], robots working cooperatively to clean-up toxic waste, underwater vehicles mapping out parts of the ocean floor [6], ect. The specific problem we address in this paper is formation control of a group of nonholonomic wheeled robots. In particular, we focus on formation maintenance while moving along prescribed trajectories. The system framework we discuss is a distributed architecture that is characterized by scalability, robustness and flexibility, compared with another extensively studied control strategy, the decentralized cooperative control as discussed in [7, 8, 9].

In multiple agents systems, one of the most important tasks is the determination of distributed protocols that agents depend on to negotiate over variables transmitted along communication channels. The protocols are termed the *consensus algorithms* and have