# Abstract

Positive systems are frequently encountered in biological systems, chemical processes, economics, social science, and in various fields of engineering. An internally positive system (also called non-negative system) maintains its states at non-negative values in presence of non-negative initial conditions and inputs. This thesis deals with two problems – the static output feedback stabilization problem for internally positive systems and the design of consensus protocol for achieving finite positive state consensus in a connected network of homogeneous positive multi-agent systems.

For solving static output feedback stabilization (SOFS) problem (an NP-hard problem) of linear time-invariant (LTI) multi-input multi-output positive systems, two iterative algorithms are proposed. Contrary to the existing literature, in this thesis, no restrictive assumption has been put on the state-space description of the open-loop plant for which a static output feedback controller is to be designed to synthesize a stable internally positive system in closed-loop. Algorithm 1 involves the cone complementarity linearization technique to overcome the underlying difficulties of bilinear matrix inequality problem, whereas Algorithm 2 depends on a scalar search technique associated with a positive definite matrix obtained as the stabilizing solution of a Riccati equation. Later, in positive systems framework, the SOFS problem is solved subject to linear quadratic (LQ) performance. This thesis also presents a solution of the robust SOFS problem in presence of interval state-space uncertainty of the open-loop positive plant. The design framework is posed in an easily solvable linear matrix inequality (LMI) framework. Further, the robust SOFS problem is extended to deal with the positive absolute stability problem in Lur'e framework where an uncertain LTI positive sub-system is interconnected with a memoryless, time-varying, sector-bounded non-linear element via positive feedback.

Next, the positive state consensus problem of a network of homogeneous linear positive agents is solved. A hierarchical control protocol is designed to achieve a finite positive state consensus in directed networks. The minimal state-space realization considered for each positive agent is not restricted to be internally positive realization, which is in contrast to the existing literature. First, a set of sufficient conditions is derived in linear programming (LP) framework solving which the unknown controller matrices involved in the consensus protocol are obtained. In order to achieve a finite positive state consensus, the local state feedback controller of the protocol synthesizes a singular Metzler system matrix which is shown either to be an irreducible matrix or to belong to a set of reducible Metzler matrices. Further, in this thesis, an observer-based hierarchical control protocol is designed for finite positive state consensus. Later, the same problem is investigated in a leader-following multi-agent systems connected over a directed network. The multi-agent network is assumed to be of homogeneous linear positive systems having a minimal and internally positive state-space realization. In the leader-follower network, the cooperative controller gain matrix is obtained by solving a set of necessary and sufficient conditions derived in LP framework.

Several numerical examples are solved throughout the thesis to illustrate the effectiveness of the proposed results.

***Keywords:*** Positive systems, Interval uncertainty, Static output feedback control, Robust control, Absolute stability, State consensus, Multi-agent systems, Hierarchical cooperative control, Metzler matrix, Irreducibility, Linear programming, Linear matrix inequality.