NONLINEAR POSITIVE OBSERVER DESIGN FOR POSITIVE DYNAMICAL SYSTEMS

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Abstract. In this paper, we address the positive observer design issue for positive dynamical systems. First, for a class of nonlinear positive dynamical systems, we establish a set of sufficient conditions for the design of a general class of positive nonlinear observers. Then, we particularly focus on the new observer design techniques for marginally stable and some unstable continuous positive linear systems. It is shown that there may not always exist a positive observer for such a continuous positive system. Nonetheless, by looking into its equivalent discrete system, the positive observers design can be successfully carried out in the discrete-time domain. This is a natural choice, as many observers and control systems are now implemented digitally on computers. We present new theorems which utilize the structural properties of sampled systems, defined by reducibility. Irreducible structure is explored as the base case and extended to reducible structure. Closed-form designs are presented for full- and reduced-order positive observers, according to the resulting conditions. In particular, for general reducible linear positive systems, a nonlinear reduced-order positive observer is proposed. Numerical examples are provided to illustrate the proposed designs.

Keywords. Positive Observer, Nonlinear Dynamical System, Irreducible System, Reducible System, Nonlinear Observer.

1 Introduction

Recent years have seen a renewed interest in positive dynamical systems since those systems are naturally involved in the study of cooperative controls of multiple dynamical systems [21] [22]. Positive dynamical systems are those systems whose state trajectories remain nonnegative, given the nonnegative initial conditions and nonnegative inputs [10] [18]. There exist many positive physical systems in practice as found in biological and economic applications.

While the system properties (such as stability) of positive systems particularly for positive linear systems have been well documented in the literature [10], it is of great interest to study the observer design for state