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STATE AND UNKNOWN INPUTS ESTIMATIONS FOR MULTI-MODEL DESCRIPTOR SYSTEMS

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ABSTRACT

This paper examines the problem of the state and the unknown inputs estimation for nonlinear descriptor system via Unknown Input and Proportional Integral Observer (PIO). The used approach is based on the multi-model representation of the nonlinear descriptor process. The design methods of both proportional integral observers and unknown inputs observers for multi-model descriptor systems are described in detail. Sufficient existence conditions of both unknown input and PI observers are given and linear matrix inequalities (LMIs) are solved to design the gains of these observers. A numerical example is provided to illustrate and to compare the design developed in this paper.

Index Terms— Nonlinear descriptor system, multi-model descriptor system, proportional integral and unknown input observer, LMIs.

1. INTRODUCTION

Nonlinear descriptor processes are usually described by analytical models. These models include both dynamic and static relations. Consequently this formalism can model physical constraints or impulsive behavior due to an improper part of the system. Descriptor systems appear in many fields of system design and control such as constrained robots, power systems, hydraulic or electrical networks.

For conventional systems, various approaches have been proposed to design observers. The observer classically used, within the framework of linear systems, is known as Luenberger observer or with profit Proportional (P) [7]. In the presence of the unknown disturbances affecting the system [11], the state estimation provided by this type of observer, is considerably degraded. In order to improve the observer design with respect to the disturbances, an observer with Proportional Integral gain can be used. Indeed, this observer makes it possible to integrate a certain degree of robustness in the state estimation thanks to the integral action [3].

Similar to the conventional linear system theory, the problem of designing observers for descriptor linear systems has been investigated by many authors. Some approaches lead to the construction of full-order and reduced-order observers [10]. Others approaches develop the concept of singular value decompositions and generalized inverse matrix [8] in order to construct the state vector for this class of systems. Some researchers have also introduced the integral term in observer design for descriptor linear systems. Indeed, in [1] and [2], a design approach of Proportional Integral Observers (PIO) for continuous time descriptor linear systems has been proposed. Koenig et al. [6], have investigated the Luenberger full-order and reduced-order (PI) observers with unknown inputs. However, few works have been done to design observers for nonlinear descriptor system except for [5]. In a recent work of Kaprielian et al. [15], a state observer based on the linearization technique of nonlinear descriptor systems with application to a physical process has been developed. In [4], an observer design for descriptor systems with Takagi-Sugeno designation has been studied. In this paper, a comparison study between two type of observers is presented. This comparison wants to underline the differences for the design of such observers and also to compare the estimation performances of them. This discussion wants to lead us which of these two observers is less restrictive for nonlinear descriptor systems represented by a Multi-Model approach.

The multi-model approach [12] consists in representing the behavior of a nonlinear system by a number of linear sub-model. Each sub-model is defined in an operating zone. The interpolation of the whole of these sub-models is carried out by weighting functions.

This paper is organized as follows: in Section 2 the Multi-Model structure of nonlinear descriptor systems is introduced. In Section 3, we study the structure and the design of the proposed proportional integral and unknown inputs multi-observer. An illustrative example is considered in Section 4.