Ann. Acad. Rom. Sci.
Ser. Math. Appl.
ISSN 2066-6594 Vol. 12, No. 1-2/2020

ON THE H_2 STATIC OUTPUT FEEDBACK CONTROL FOR HIDDEN MARKOV JUMP LINEAR SYSTEMS*

André M. de Oliveira† Oswaldo L. V. Costa‡

DOI https://doi.org/10.56082/annalsarscimath.2020.1-2.405

Dedicated to Dr. Vasile Drăgan on the occasion of his 70th anniversary

Abstract

In this chapter we discuss the H_2 control for Markov jump linear systems in a context of partial observation of both the Markov chain and the state variable. The controller is static and depends on an observed variable that provides the only information of the Markov variable in a context of hidden Markov chains. We propose a new design condition in terms of linear matrix inequalities considering rank constraints in suitable system matrices that are easily fulfilled. Next we investigate the case in which the detector provides perfect estimations of the Markov chain and all the states are available to the controller. Finally we compare this result with the so-called two-step procedure for hidden Markov jump linear systems in an academic example of a

*Accepted for publication in revised form on July 4, 2020

†andre.marcorin@unifesp.br Institute of Science and Technology, Federal University of São Paulo (UNIFESP), Av. Cesare Mansueto Giulio Lattes, 1201 - Eugênio de Mello, São José dos Campos, SP, CEP: 12247-014, Brazil. Paper written with financial support of the National Council for Scientific and Technological Development grants CNPq-304149/2019-5; the FAPESP/Shell through the Research Center for Gas Innovation grant FAPESP/Shell-2014/50279-4; the project INCT, grants CNPq/INCT-465755/2014-3 and FAPESP/INCT-2014/50851-0; and the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - CAPES, Finance Code 88887.136349/2017-00.

‡Departamento de Engenharia de Telecomunicações e Controle, Escola Politécnica na Universidade de São Paulo (EPUSP), Avenida Professor Luciano Gualberto, trav. 3, n. 158, São Paulo, SP, CEP: 05508-010, Brazil.

system subject to faults.
MSC: 93C05, 93C55, 93E20, 60J10, 93E25

keywords: Stochastic control; H_2 control; static output feedback control; Markov processes; linear matrix inequalities

1 Introduction

Systems subject to abrupt changes in their dynamics have been receiving a great deal of attention in the past decades. One of the main reasons concerns the presence of faults in critical applications, which motivates to develop a deeper understanding of how to detect and consequently act in such cases. Specially if the changes are not deterministic, as it is usually the case, the use of Markov jump linear systems (MJLS) to model these situations is appealing. By now there is a large body of works on MJLS such as [13, 5, 6, 22, 2] and the reference therein, to name a few.

The aforementioned works deal mainly with the case in which the Markov chain can be measured, the so-called mode-dependent or perfect observation case. However there are instances in which the Markov chain is not available to the control, as in applications of Active Fault-tolerant Control Systems (AFTCS) in [21, 1] in which the main jump process is a fault process. This setting imposes challenging problems in a vast array of applications going from control to filtering, see, for instance, [42, 15, 17, 18, 12, 16, 3], and the references therein. Among the approaches dealing with the so-called *partial observation setting* of the Markov chain used in the aforementioned works, we can point out the *cluster* and *mode-independent* cases. In the former setting, the modes of operation are grouped into distinguishable and disjoint sets so that the controller/filter would jump according to the set in which the Markov chain is currently operating; and the latter assumes that there is no information at all concerning the jump process so that there is only one controller for all possible modes of operation. More recently, an alternative formulation introduced in [4] that encompasses the aforementioned approaches has come into a great focus in the literature. The idea is to study the problem in the context of hidden Markov chains, see for instance, [34], so that even though the Markov chain is hidden, there is still some information provided by a type of *detector*, for instance, the output of a Fault-detection and Isolation device (FDI), that could be used in the control of the system. We can mention a few works such as [7, 43, 29, 41] concerning state-feedback control; [27, 32, 37] for filtering; [9, 20] for dynamic output feedback control;