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REACHABILITY OF SWITCHED LINEAR DISCRETE-TIME SYSTEMS WITH STATE DELAYS

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Abstract. This paper investigates the reachability and controllability of switched linear discrete-time systems with state delays. Necessary and sufficient geometric criteria for reachability and controllability of such systems are derived. For reversable systems, it is proved that the controllability is equivalent to the reachability, and verifiable criterion is established as well. Furthermore, these results are extended to the case of multiple state delays. Our results generalize the existent results on switched linear systems without time delay.
Keywords. Switched linear systems, discrete-time, state delay, reachability, controllability.
AMS (MOS) subject classification: 93B07, 93B12, 93B99

1 Introduction

Switched linear systems are an important class of hybrid systems, which is a collection of a set of subsystems described by differential/difference equations and a switching rule specifying the switching between them. If the subsystems are described by differential equations, the system is generally called a switched linear continuous-time system; if they are described by difference equations, it is called a switched linear discrete-time system.

Controllability and observability are the two most fundamental concepts in modern control theory [1], [2], and [3]. They have close connections to pole assignment, structural decomposition, quadratic optimal control and observer design, etc. Controllability and observability of switched linear systems have been studied in a number of papers.

For continuous-time switched linear systems, [4] first studied the one-period controllability and observability for periodically switched systems, and some sufficient and necessary conditions were established. Then [5] introduced the multiple-period controllability and observability concepts naturally extended from the one-period ones, and necessary and sufficient criteria were derived. It was also pointed out that the controllability can be realized in n periods at most, where n is the state dimension. As to arbitrarily switched linear systems, [6] first gave a sufficient condition and a necessary condition for controllability, and proved that the necessary condition is also sufficient for 3-dimensional systems with only two subsystems. Then, [7] extended the result to 3-dimensional systems with arbitrary number of subsystems. Necessary and sufficient geometric type criteria for controllability and observability of such systems were derived in [8] and [9]. Furthermore, it was proved that the controllability can be realized by a single switching sequence in [9] and [10], and a direct consequence is the criterion given in [8] and [9]. Subsequently, [14] extended these results to periodically and/or arbitrarily switched systems with multiple time-delays in control.

For discrete-time switched linear systems, the corresponding results were also built up. [11] and [12] gave a necessary and sufficient criterion for controllability. In [13], it was proved that the controllability can be realized by a single switching sequence under some mild conditions. For discrete-time switched linear systems with time-delays, [17]