УДК 681.51

COMPENSATION OF INPUT AND OUTPUT DISTURBANCES FOR MIMO DISCRETE-TIME SYSTEMS WITH UNMEASURED STATE VECTOR

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Introduction. The problem of compensating for external disturbances is a fundamental and practical issue in automatic control theory [1-3]. One of the widely used approaches is based on the internal model principle (IMP) [1-5], where the external signals (exosignals) are described by the output of an autonomous linear generator. The IMP proves to be an efficient approach for handling external exosignals that need to be rejected or tracked. This principle involves modeling the reference signal to be tracked or the disturbance to be rejected as the output of an autonomous dynamic system, referred to as an exosystem, driven by the nonzero initial conditions of its state. By appropriately replicating the exosystem model within the closed-loop system's structure, it becomes possible to achieve asymptotic tracking of the reference signal or completely neutralize the effect of the disturbance. If the parameters of the control system and the external disturbance are known, the disturbance compensation problem can be solved using a nonadaptive controller with fixed precalculated parameters [6], [7]. In this paper, we focus on the nonadaptive implementation of the external disturbance compensation problem. Regarding this issue, study [2] provided a comprehensive presentation of the implementation of the control law and the construction of a state observer based on the internal model principle. However, the investigated system was a continuous-time single-input single-output linear system, considering the influence of input disturbances. Building upon this work, study [1] developed a control law for continuous-time linear MIMO systems affected by both input and output disturbances, assuming that the system states could be directly measured. As a result, a state observer was not constructed in that study. To estimate the system states for external disturbance compensation [8], observers with unknown input signals have been used. However, this study have only been applied to continuous-time MIMO systems affected by input disturbances. Therefore, the application of this approach to a class of discrete-time multichannel systems affected by both input and output disturbances remains an open question. In this paper, we propose a new method for designing a external disturbance compensation control law, applicable to discrete-time MIMO linear systems affected by both input and output disturbances, where the system states cannot be directly measured.

Main Part. This paper proposes the problem of external disturbance compensation control for a class of discrete-time linear multi-channel systems affected by both input and output disturbances. It is assumed that the control plant and the external disturbance signals have known parameters; however, the system states cannot be directly measured. The solution to this problem is based on the use of the Francis equation and a discrete-time PID observer. A full-order observer with unknown input signals (Discrete-Time PID Observer) is synthesized to solve the problem of estimating the state vector of the system when the system is affected by external disturbances on both the input and output. Based on the Francis equation, a regulator is designed to compensate for external disturbances, ensuring the robust stability of the system. The performance of the obtained results is validated through computer simulations in MATLAB Simulink.

Conclusions. This study presents an approach to designing disturbance compensation controllers for discrete-time linear MIMO systems affected by both input and output disturbances, assuming that the system states cannot be directly measured. The simulation results indicate that although the PID observer does not achieve exact asymptotic estimation, it can ensure that the estimation error remains within a certain bound when the disturbance between two consecutive sampling points does not vary significantly. Additionally, the proposed control law effectively compensates for external disturbances, ensuring the robust stability of the system.

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