Fixed-time stability of nonlinear impulsive dynamical systems

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Abstract. The present article is concerned with the fixed-time stability analysis of the nonlinear dynamical systems with impulsive effects. The novel criteria have been derived to achieve stability of the nonlinear dynamical system in fixed-time under the effects of stabilizing and destabilizing impulses. The fixed time stability analysis due to the presence of destabilizing impulses in dynamical system, that leads to behaviour of perturbing the systems' stability, have not been addressed much in the existing literature. Therefore, two theorems are constructed here, for stabilizing and destabilizing impulses separately, to estimate the fixed-time convergence precisely by using the concept of Lyapunov functional and average impulsive interval. The theoretical derivation shows that the estimated fixedtime in this study is less conservative and more accurate as compared to the existing fixed-time stability theorems.

Introduction

Finite-time stability (FTS) and control problems of nonlinear dynamical systems have drawn considerable attention in recent years and become one of the active research areas in the field of nonlinear control. FTS can ensure that a system's state trajectories converge to the ideal state after some finite-time [1], which is called the settling-time or convergence time of the system. It is worth to be noted that the settling-time in FTS depends heavily on the initial states of the system, which makes the settling-time vary for different initial conditions. Moreover, the knowledge of initial conditions of many practical systems is hardly accurate or impossible to obtain in advance which leads to the poor estimation of the settling time. To overcome this difficulty, Polyakov presented a novel concept called the fixed-time stability (FXTS) in [2]. If the system is globally FTS and the settling-time function is a constant for any initial values, i.e, bounded and independent of the initial conditions then the system is called FXTS. The Impulsive dynamical system is an important type of hybrid system which consists of two parts: one is a continuous part and another is a discrete part. There can be different types of impulses considered in dynamical systems. In general, the impulses which are favorable for the systems' stability are called stabilizing impulses (absolute value of impulses is less than one), whereas the impulses whose absolute value is greater than one are termed as destabilizing impulses. Stabilizing impulses control the states of the systems at impulsive points so those act as impulsive controls whereas destabilizing impulses act like perturbations for the systems' stability. In [3], the author investigated FXTS of nonlinear dynamical systems with stabilizing impulses but the destabilizing impulses were not taken into consideration. Therefore, it is worth to contribute to the analysis on the result of FXTS of impulsive system with destabilizing impulses.

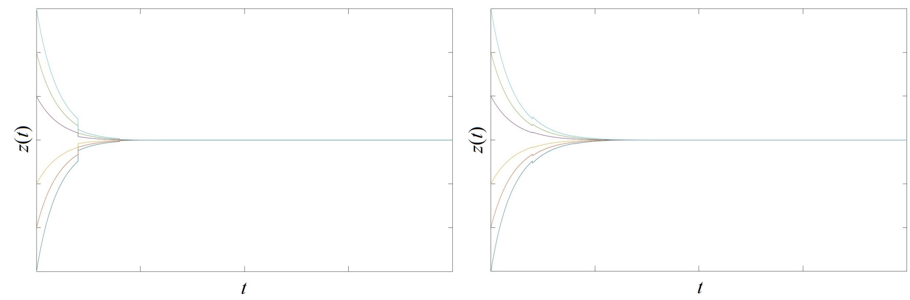

Figure 1: System state trajectories with stabilizing (left) and destabilizing (right) impulses.

Results and discussion

Different from the previous article reported by Li et al. [3], in this present article, the authors have contributed a novel FXTS of nonlinear systems with destabilizing and stabilizing impulses (Fig. 1). Based on the idea of Lyapunov stability theory and the concept of average impulse interval, two novel FXTS theorems are established and derived the high-precision settling-time estimate. It is to be mentioned here that our estimate is more accurate and less conservative as compared to the classical result presented in [3]. Although in [3], it was stated that FXTS cannot be guaranteed in the case of destabilizing impulses, contrary to this claim, our results demonstrated that FXTS can be guaranteed in the case of destabilizing impulses under some sufficient conditions.

References

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