Stabilizing-delay-based impulsive control for cluster synchronization of nonlinearly coupled Lure networks

Deli Xuan[*], Ze Tang[*],Ju H. Park[**]

[*]*School of Internet of Things Engineering, Jiangnan University, Wuxi 214122, PR China.*

[**]*Department of Electrical Engineering, Yeungnam University, 280 Daehak-Ro, Kyonsan 38541, Republic of Korea.*

Abstract. This paper considers the global and exponential cluster synchronization problem for a kind of nonlinearly and nonidentically coupled Lur'e dynamical networks with an asymmetrical coupling matrix. With considering the cluster-tree topology structures of the networks, a novel delayed impulsive pinning control protocol is proposed, which only imposed on the Lur'e systems in current cluster which have directed paths with those Lur'e systems in the other clusters. Furthermore, to simulate more practical situations, the stabilizing effects of time-delay in impulses are fully considered. In view of the Lyapunov stability theorem, mathematical induction method and average impulsive interval, sufficient conditions that ensure the realization of the cluster synchronization for nonlinearly coupled Lur'e dynamical networks are derived with different initial values. Finally, the validity of the theoretical analysis and control schemes are illustrated by means of a numerical experiment.

Introduction

In this paper, we explore some interesting results related to the global and exponential cluster synchronization of a kind of nonlinearly and nonidentcially coupled Lur'e dynamical networks. In most of existing results discussed the impulsive control issues, for instance in [1, 2], they only focus on the impulsive control with destabilizing time-delay for the synchronization of the complex networks. In contrast, we propose an impulsive pinning control protocol with stabilizing delay to archive the cluster synchronization for the Lur'e networks.
To the best of authors' knowledge, the global and exponential cluster synchronization of nonlinearly coupled Lur'e dynamical networks with an asymmetrical matrix, until now, receives little attention. It motivates us to investigate this work based on the stabilizing time-delay in impulsive pinning control. In this paper, the distinguished features different from other papers can be summarized as: (1) The global and exponential cluster synchronization of nonlinearly coupled Lur'e dynamical networks with an asymmetrical matrix is explored under the impulsive controller with stabilizing delay; (2) A kind of pinning feedback controllers is elaborately designed which only imposed on the Lur'e systems in the cluster that exist directed connections with the Lur'e systems in other clusters by considering the cluster-tree topology structures of the nonlinearly and nonidentically coupled Lur'e networks, which is more practical and closer to real situations than some previous works, like *Wu et al*. in [3]; (3) By introducing the average impulsive interval, sufficient conditions for the exponential cluster synchronization of nonlinearly coupled Lur'e dynamical networks are obtained in view of the Lyapunov stability theorem, mathematical induction method and the projection method.

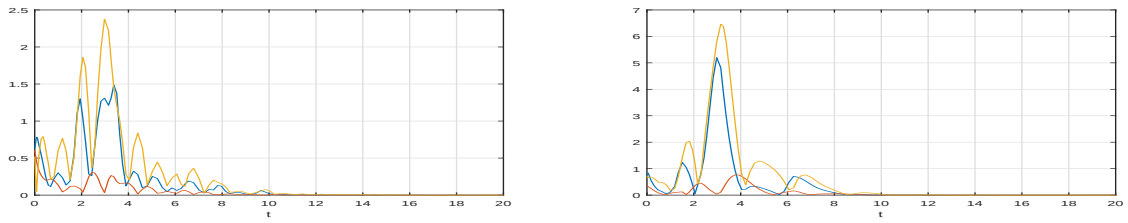

Figure 1: The state error curves of the Lur'e systems in two different clusters.

Results and Discussion

This paper has proposed an impulsive pinning control protocol with stabilizing delay for the cluster synchronization issue of a class of nonlinearly coupled Lur'e networks with an asymmetrical coupling matrix. By introducing the average impulsive interval and applying the Lyapunov stability theorem as well as mathematical induction method, sufficient conditions have been derived that ensure the realization of the global and exponential cluster synchronization for the Lur'e networks. Finally, a numerical example has been implemented to prove the correctness of the theoretical analyses and control schemes (see figure 1).

References

[1] He WL, Qing F, Cao JD. Pinning-controlled synchronization of delayed neural networks with distributed-delay coupling via impulsive control. Neural Networks. 2017;85:1-9.

[2] Zhang X, Li X, Cao J, et al. Design of memory controllers for finite-time stabilization of delayed neural networks with uncertainty. Journal of the Franklin Institute. 2018;355(13):5394-5413.

[3] Wu W, Zhou WJ, Chen TP. Cluster synchronization of linearly coupled complex networks under pinning control. IEEE Transactions on Circuits and Systems. Part I: Regular Papers. 2009;56(4):829-839.