Collective periodic motions in a multi-particle model involving processing delay

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Abstract

How to understand the dynamical collective performances is of particular significance in both theories and applications. In this paper, we are interested in investigating the combined influences of local interaction and processing delay on the asymptotic behaviour in a particle model with local communication weights. As new observations, we show that the desired particle system undergoes both periodic flocking and periodic clustering behaviors when the processing delay crosses a threshold value and the eigenvalue 1 of average matrix is semi-simple. In this case, the connectedness of the particle system may be absent. Also, the number of clusters is discussed by using the subspace analysis. In results, some criterion of flocking and clustering emergence with exponential convergent rate are established by the standard functional differential equations analysis when the processing delay is small. When the processing delay reaches the threshold value, the system undergoes periodic flocking and periodic clustering emergence. It also shows that the processing time lags qualitatively change the emergent performances in a nonlinear way. Finally, we conclude this study with several numerical simulations that intuitively illustrate the validity of the theoretical results and address some discussions for both variable communication weight and distributed processing delay.

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