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Optimal control of discrete-time fractional multi-agent systems

By an emergent collective behavior in multi-agent systems we mean interactions between individual agents that yield distinct patterns at the level of the group. This behavior cannot be understood simply as the sum of its constituent parts. Moreover, individual actions affect group outcomes, group outcomes feed back to affect individual actions. This behavior is widespread in the nature, for example in the form of flocking of birds or schooling of fish.

In this work we focus on discrete-time fractional multi–agent systems and investigate optimal control strategies for two variants of those type of systems. First, we consider a problem with single-integrator dynamics, that is each agent is described by time-dependent consensus parameter $x_i(t) \in \mathbb{R}$, $i = 1, \ldots, N$, which could represent a certain physical/economic/social quantity such as attitude, position, temperature, price, opinion and so on. In the situation when the system does not converge to a consensus or there is a demand to reach a consensus faster it is natural to use external control strategies. This control policy should be designed in the most economical way. Therefore, we minimize control and disagreements among agents. Next, we consider a problem with double-integrator dynamics, that is each agent is represented by two coordinates $(x_i(t), v_i(t)) \in \mathbb{R}^2$, where $x_i(t) \in \mathbb{R}$ and $v_i(t) \in \mathbb{R}$ are the time-dependent state and consensus parameter, respectively. The motivation for using fractional operators is twofold. First, the integer-order systems are just particular cases of fractional-order ones. Second, different from integer-order systems fractional-order systems can offer a deeper insight into processes underlying a long range memory behavior.

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References

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