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Moments driven predictive control of mean-field collective dynamics

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The study of collective behaviour phenomena from a multiscale modeling perspective has seen an increased level of activity over the last years. Classical examples in socio-economy, biology, and robotics are given by self-propelled particles that interact according to a nonlinear model encoding various social rules as for example attraction, repulsion, and alignment.
Of particular interest for control design purposes is understanding the impact of control inputs in such complex systems and the study of mean-field control approaches where the control law obtain formal independence on the number of interacting agents. The construction of computational methods for mean-field optimal control is a challenging problem due to the nonlocality and nonlinearity arising from the dynamics. Furthermore, depending on the associated cost to be minimized, non-smooth and/or non-convex optimization problems might also arise.
In order to circumvent these difficulties, we propose a linearization-based approach for the computation of sub-optimal feedback laws obtained from the solution of differential matrix Riccati equations. Quantification of the dynamic performance of such control laws leads to theoretical estimates on suitable linearization points of the nonlinear dynamics. Subsequently, the feedback laws are embedded into a nonlinear model predictive control framework where the control is updated adaptively in time according to dynamic information on moments of linear mean-field dynamics. The performance and robustness of the proposed methodology are assessed through different numerical experiments in collective dynamics.

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