A Learning-Based Model Predictive Control Framework with an State Observer for Epidemic Mitigation

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Many applications have shown the use and success of classical compartment models in estimating the states and evolution of disease spreads. Similarly, the study of Optimal Control Theory has shown positive results in those scenarios but, sometimes, lack computational and theoretical tractability, specially in the cases of long-term problems or uncertain scenarios. In that context, Model Predictive Control (MPC) has become apparent, as it provides a more tractable version of a (Stochastic) Optimal Control Problem by approximating the solution through a simplified version of the control problem over a shorter horizon. Nevertheless, the current state or uncertainty can affect the local optimal solution, what provides niche to the introduction of learning methods in the process [2].

The works in [3], [1] propose approaches considering social distancing for control strategy due to the lack of vaccines in the early stages of the SARS-CoV-2. More recently, the authors in [4] used a learning-based MPC iterative framework for epidemic mitigation introducing a real-time strategy, proposing the use of linear regression for parameter estimation, and testing for isolation as control strategy. Also, as part of the MPC schema, the authors in [1] also present a *state observer*, an asymptotically stable estimator of the unreliably observed states.

From this perspective, we propose a Learning-Based Model Predictive Control strategy for a *susceptible-infected-recovered-quarantine (SIRQ)* model for an uncertain scenario, where one has only reliable measures of the population in (Q)uarantine. For this work a testing for isolation control strategy is proposed, also considered reliably measurable.

As in [4], we consider a interactive framework of parameter estimation and feedback control computation. Differently from the previous, we propose the use of a long short-term memory (LSTM)-Based State Observer, a deep learning algorithm for sequential data, for hidden state and parameter estimation, provided to the control computation. This kind of algorithm has previously shown positive results in epidemic prediction, for inferring disease states and future outcomes [5].

We show how this kind of approach could be a reliable option for epidemic disease mitigation. Future works include the discussion of a more complete set of compartments, for vaccine effectiveness estimation, and robust control under uncertain vaccination availability.

Acknowledgement

This work is part of an MSc project study suported by the FGV EMAp and CAPES, under the advisory of professor Maria Soledad Aronna. The current research is also funded by FAPERJ through the Jovem Cientista de Nosso Estado Programme Process E-26/203.223/2017 and by CNPq (Brazil) through Process 312407/2023-8.

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