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Editorial

Third special section on systems and control research efforts against COVID-19 and future pandemics

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The World Health Organization (WHO) declared the novel coronavirus outbreak a Public Health Emergency of International Concern on 30 January 2020, and a pandemic on 11 March 2020. Since then, the COVID-19 pandemic has radically transformed our way of working, communicating, socializing, commuting, shopping, and educating, amongst many aspects of our lives. Amongst the many lessons learned in almost two years with COVID-19, non-pharmaceutical interventions and vaccines have been recognized as major countermeasures against SARS-CoV-2. Nevertheless, new COVID-19 outbreaks are still occurring, saturating public health capacity.

Mathematical models and simulations have played a central role to design public health measures, such as enforcing and removing physical distancing, throughout the COVID-19 pandemic. Here, we present the last special section of a trilogy (Hernandez-Vargas et al., 2020), (Hernandez-Vargas et al., 2021) with a total of 29 articles, developing "fast solutions" to respond to COVID-19, as well as advancing computational tools and our understanding of not only the COVID-19 pandemic but also future pandemics. This third special section includes the following ten articles:

The first paper is entitled **"Data-driven methods for present and future pandemics: monitoring, modelling and managing"** by Teodoro Alamo, Daniel Gutiérrez Reina, Pablo Millán Gata, Victor Manuel Preciado, and Giulia Giordano. The authors present an ample and thorough survey following a roadmap from the access to epidemiological data sources to the control of epidemic phenomena, based on a 3M-analysis (Monitoring, Modelling, and Managing) method. Available data-driven methodologies and models are discussed, as well as the challenges in the development of strategies to combat the spread of infectious diseases.

The second article is a tutorial entitled **"Crowd management COVID-19″** by Liliana Durán Polanco, and Mario Angel Siller. The authors uncover the importance of modelling crowds as a source of transmission in COVID-19 spread. They propose a computational algorithm based on game theory to predict the user's choice and estimate the crowd level for the requested points-of-interest. This work is particularly important to monitor and manage crowd levels in interior places, such as shopping centers or stores.

The third article, authored by Yuga Onoue, Kazumune Hashimoto, Masaki Ogura, and Toshimitsu Ushio, is entitled **"Event-triggered control for mitigating SIS spreading processes"**. The authors present an event-triggered control formulated in the context of viral spreading, in which the number of medical treatments and the level of traffic regulations for each subpopulation are updated only when a fraction of the infected people in the subpopulation exceeds a prescribed threshold. The effectiveness of the proposed approach is illustrated by numerical simulations using an air transportation network, which is particularly relevant given the now-dominant delta-variant aerosolizes for airborne transmission.

Also focused on tailoring non-pharmaceutical interventions for COVID-19 is the fourth paper, entitled **"Multitask learning and nonlinear optimal control of the COVID-19 outbreak: a geometric programming approach"** by Mikhail Hayhoe, Francisco Barreras, and Victor M. Preciado. This paper proposes a multitask approach to learn the parameters of a discrete-time epidemic model from diverse data sources and use it to design optimal control strategies of mobility restrictions to both curb the epidemic and minimize the economic costs associated with implementing non-pharmaceutical interventions. Results are illustrated with simulations using data from the COVID-19 pandemic in the Philadelphia metropolitan area.

The fifth paper is entitled **"Hysteresis-based supervisory control with application to non-pharmaceutical containment of COVID-19″** by Michelangelo Bin, Emanuele Crisostomi, Pietro Ferraro, Roderick Murray-Smith, Thomas Parisini, Robert Shorten, and Sebastian Stein. The authors focus on the problem of adapting the policy characteristics

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online from measurements. The article puts forth a general theory of hysteresis control, derived in a broad context unrelated with epidemics, and then presents a refined version of the theory specialised to the context of epidemics containment, along with extensive numerical analysis on models specific for COVID-19.

The sixth article is entitled **"Non-integer (or fractional) power model to represent the complexity of a viral spreading: application to the COVID-19″** by Alain Oustaloup, François Levron, Stéphane Victor, and Luc Dugard. The authors present a simple deterministic mathematical model by using a power law. This non-integer power model (or fractional power model) enables representing the totality of the contaminated individuals at each day, which makes this tool of interest for time series analysis. The results are illustrated with the official data of the French Ministry of Health on the COVID-19 spreading.

The seventh paper is authored by Tamás Gábor Péni and Gábor Szederkényi and is entitled **"Convex output feedback model predictive control for mitigation of COVID-19 pandemic"**. Based on a suboptimal solution, obtained by geometric programming or by a linear programming approximation, the authors developed a model predictive control approach for epidemic mitigation based on a nonlinear model of the COVID-19 pandemic in Hungary. The novelty in this approach is the authors assumed hospitalized people are the only online measured variable, and the other state variables are computed using a state observer based on the dynamic inversion of a linear sub-system of the model.

The eighth paper, entitled **"Modelling and control of epidemics through testing policies"**, is authored by Muhammad Umar B. Niazi, Alain Kibangou, Carlos Canudas-de-Wit, Denis Nikitin, Liudmila Tumash, and Pierre-Alexandre Bliman. The authors highlight a very crucial control mechanism in the early phase of an epidemic, which is testing. In this paper, an epidemic model incorporates the testing rate as a control input and differentiates undetected from detected infection cases. Testing policies are evaluated in terms of their impact on the number of active intensive care unit cases and the cumulative number of deaths for the COVID-19 case of France.

"COVID-19 epidemic control using short-term lockdowns for collective gain" is the ninth paper, authored by Gianluigi Pillonetto and Mauro Bisiacco. The so-called Australian model (short and sharp responses to tame the epidemic, within a "short-term pain for collective gain" strategy framework) is analysed in the context of sliding-mode control. This approach provides important insights for implementing short-term lockdowns and better understanding their merits and/or possible limitations. The results highlight the COVID-19 epidemic could be controlled by alternating one or two weeks of complete lockdown with one or two months of freedom.

The tenth paper, authored by Pablo Abuin, Alejandro Anderson, Antonio Ferramosca, Esteban A. Hernandez-Vargas, and Alejandro Gonzalez, is entitled "**Dynamical characterization of antiviral effects in COVID-19″**. Using a mathematical model at the in-host level to describe the interactions between the immune system and viral dynamics is instrumental in this article to settle antiviral effectiveness thresholds to establish whether or not a potential treatment will be able to clear the infection. Simulations show the potential clinical benefits of a treatment classification according to the patient's critical parameters.

The guest editors are grateful to all the authors and reviewers of these three special sections in the Annual Reviews in Control. While the COVID-19 pandemic is still ongoing after almost two years, this trilogy of special sections provides important control-theoretic contributions to deal with the new outbreaks of COVID-19 and with future pandemics caused by new or emerging pathogens. The guest editors also thank the Editor-in-Chief, Prof. Francoise Lamnabhi-Lagarrigue, and her journal team for pushing forward this project during a public health emergency like COVID-19.

Declaration of Competing Interest

The author(s) declare(s) that there is no conflict of interest.

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