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Introduction to the Special Track on Artificial Intelligence and COVID-19

Martin Michalowski MARTINM@UMN.EDU
University of Minnesota, Minneapolis MN USA

Robert Moskovitch ROBERTMO@BGU.AC.IL
Ben-Gurion University of the Negev, Beersheba Israel

Nitesh V. Chawla NCHAWLA@ND.EDU
University of Notre Dame, Notre Dame IN USA

Abstract

The human race is facing one of the most meaningful public health emergencies in the modern era caused by the COVID-19 pandemic. This pandemic introduced various challenges, from lock-downs with significant economic costs to fundamentally altering the way of life for many people around the world. The battle to understand and control the virus is still at its early stages yet meaningful insights have already been made. The uncertainty of why some patients are infected and experience severe symptoms, while others are infected but asymptomatic, and others are not infected at all, makes managing this pandemic very challenging. Furthermore, the development of treatments and vaccines relies on knowledge generated from an ever evolving and expanding information space. Given the availability of digital data in the modern era, artificial intelligence (AI) is a meaningful tool for addressing the various challenges introduced by this unexpected pandemic. Some of the challenges include: outbreak prediction, risk modeling including infection and symptom development, testing strategy optimization, drug development, treatment repurposing, vaccine development, and others.

1. Introduction

In this special track on Artificial Intelligence and COVID-19, we invited submissions on how data science/AI advancements are addressing challenges related to the global pandemic, including deployments and practical experiences in deploying AI to cope with COVID-19. The response to our call for papers was robust with 24 papers submitted and four accepted. The special track consists of the following papers:

1. Myrl G. Marmarelis, Greg Ver Steeg and Aram Galstyan. *A Metric Space for Point Process Excitations*
2. Greg M. Silverman, Himanshu S. Sahoo, Nicholas E. Ingraham, Monica Lupei, Michael A. Puskarich, Michael Usher, James Dries, Raymond L. Finzel, Eric Murray, John Sartori, Gyorgy Simon, Rui Zhang, Genevieve B. Melton, Christopher J. Tignanelli and Serguei V.S. Pakhomov. *NLP Methods for Extraction of Symptoms from Unstructured Data for Use in Prognostic COVID-19 Analytic Models*
3. Roberto Capobianco, Varun Kompella, James Ault, Guni Sharon, Stacy Jong, Spencer Fox, Lauren Meyers, Peter R. Wurman and Peter Stone. *Agent-Based Markov Modeling for Improved COVID-19 Mitigation Policies*

4. Cédric Colas, Boris Hejblum, Sebastien Rouillon, Rodolphe Thiébaut, Pierre-Yves Oudeyer, Clément Moulin-Frier and Mélanie Prague. *EpidemiOptim: A Toolbox for the Optimization of Control Policies in Epidemiological Models*

Marmarelis et al. describe a multivariate Hawkes process enabling self- and cross-excitations through a triggering matrix that behaves like an asymmetrical covariance structure, characterizing pairwise interactions between the event types. They propose a Hidden Hawkes Geometry (HHG) model to uncover the hidden geometry between event excitations in a multivariate point process. The HHG model is used to investigate regional infectivity dynamics of COVID-19 in South Korean record and in Los Angeles confirmed cases. They also perform synthetic experiments on short records as well as explorations into options markets and the Ebola epidemic, demonstrating that learning the embedding alongside a point process uncovers salient interactions in a broad range of applications.

Silverman et al. explore how statistical modeling of outcomes based on a patient's presenting symptoms (symptomatology) can help deliver high quality care and allocate essential resources, which is especially important during the COVID-19 pandemic. Patient symptoms are typically found in unstructured notes, and thus not readily available for clinical decision making. In an attempt to fill this gap, they compared two methods for symptom extraction from Emergency Department (ED) admission notes. Both methods utilized a lexicon derived by expanding The Center for Disease Control (CDC) and Prevention's Symptoms of Coronavirus list. Their findings suggest that prognostic models based on symptomatology could aid in extending COVID-19 patient care through telemedicine, replacing the need for in-person options. The methods presented in their study have potential for use in development of symptomatology-based models for other diseases, including for the study of Post-Acute Sequelae of COVID-19 (also known as long COVID).

Capobianco et al. focus on epidemiological models that provide insight into the spread of disease and predict the effects of possible intervention policies. They study how reinforcement learning (RL) and Bayesian inference can be used to optimize mitigation policies that minimize economic impact without overwhelming hospital capacity. Their main contributions are (1) a novel agent-based pandemic simulator which, unlike traditional models, is able to model fine-grained interactions among people at specific locations in a community; (2) an RL-based methodology for optimizing fine-grained mitigation policies within this simulator; and (3) a Hidden Markov Model for predicting infected individuals based on partial observations regarding test results, presence of symptoms, and past physical contacts.

Colas et al. model the dynamics of epidemics to propose control strategies based on pharmaceutical and non-pharmaceutical interventions. They cast the task of building control strategies as an optimization problem. They introduce EpidemiOptim, a Python toolbox that facilitates collaborations between researchers in epidemiology and optimization. EpidemiOptim turns epidemiological models and cost functions into optimization problems via a standard interface commonly used by optimization practitioners (OpenAI Gym). They illustrate the use of EpidemiOptim to find optimal policies for dynamical on-off lockdown control under the optimization of the death toll and economic recess using a Susceptible-Exposed-Infectious-Removed model for COVID-19. Using EpidemiOptim and its interactive visualization platform, epidemiologists, optimization practitioners, and others (e.g. economists) can easily compare epidemiological models, costs functions, and optimization algorithms to address important choices to be made by health decision-makers.

2. Discussion

Since the detected spread of COVID-19, a meaningful amount of research has been performed that uses AI-based methods in the analysis of data, in the attempt to repurpose existing drugs, in understanding who is susceptible to the virus and who will get severe symptoms, and even in developing a cure. The four papers accepted for the special track clearly demonstrate the breadth of possibilities enabled by AI in mitigating the effects of COVID-19, with application to future public health crises. It is our hope that continued work in this space will reduce the impact of COVID-19 on current life and improve pandemic response moving forward.

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