

Title: Inferring Spatial Source of Disease Outbreaks using Maximum Entropy

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Mathematical modeling of disease outbreaks can infer the future trajectory of an epidemic, allowing for making more informed policy decisions. Another task is inferring the origin of a disease, which is relatively difficult with current mathematical models. Such frameworks, across varying levels of complexity, are typically sensitive to input data on epidemic parameters, case-counts and mortality rates, which are generally noisy and incomplete. To alleviate these limitations, we propose a maximum entropy framework that fits epidemiological models, provides a calibrated infection origin probabilities, and is robust to noise due to a prior belief model. Maximum entropy is agnostic to the parameters or model structure used and allows for flexible use when faced with sparse data conditions and incomplete knowledge in the dynamical phase of disease-spread, providing for more reliable modeling at early stages of outbreaks. We evaluate the performance of our model by predicting future disease trajectories in synthetic graph networks and the real mobility network of New York state. In addition, unlike existing approaches, we demonstrate that the method can be used to infer the origin of the outbreak with accurate confidence (expected calibration error =0.123). Indeed, despite the prevalent belief on the feasibility of contact-tracing being limited to the initial stages of an outbreak, we report the possibility of reconstructing early disease dynamics, including the epidemic seed, at advanced stages. This approach is easily generalizable to similar classes of spreading reaction-diffusion processes such as rumors and misinformation in social media or computer viruses throughout the Internet.

Biography

Mehrad Ansari is a PhD candidate of chemical engineering at the University of Rochester, NY, USA. His research is mostly focused on physics-informed machine learning by creating a bridge between sophisticated physics-based models and data-driven approaches to exploit complimentary.

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