Mathematical Models of Epidemics: Aggregating Stochastic Dynamics

Grzegorz A. Rempala[1]

[1]The Ohio State University

Abstract:
Motivated by the classical Susceptible-Infected-Recovered (SIR) epidemic models and the data from current COVID-19 pandemic, we consider a class of 'monotone transition' stochastic dynamical systems (SDSs) under the mass-action law. We show that the dynamics of such SDSs may be approximately described in terms of implicit survival functions and certain random measures. This survival interpretation allows us to employ tools from statistical theory of survival analysis to address various issues with data collection and statistical inference in classical SIR models. It also offers an alternative to more standard statistical methods based on the theory of hidden Markov processes. In particular, we propose and numerically validate a statistical inference procedure for SDS-likelihoods that is relying on observed marginal likelihoods generated by typically epidemic curves. Only a slightly more complicated SDS model was successfully used by the state of Ohio to predict the amount of state COVID-19 burden in the early months of the 2020 pandemic. If time permits, I will also briefly outline the main ideas behind that specific model.

Keywords:
Stochastic dynamics; SIR model; Survival analysis; Epidemic curve; COVID-19

References:
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