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Parameter Estimation for Contact Tracing in Graph-Based Models

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Abstract : We adopt a maximum-likelihood framework to estimate parameters of a stochastic susceptible-infected-recovered (SIR) model with contact tracing on a rooted random tree. Given the number of detectees per index case, our estimator allows to determine the degree distribution of the random tree as well as the tracing probability. Since we do not discover all infectees via contact tracing, this estimation is non-trivial. To keep things simple and stable, we develop an approximation suited for realistic situations (contract tracing probability small, or the probability for the detection of index cases small). In this approximation, the only epidemiological parameter entering the estimator is the basic reproduction number R0. The estimator is tested in a simulation study and applied to covid-19 contact tracing data from India. The simulation study underlines the efficiency of the method. For the empirical covid-19 data, we are able to compare different degree distributions and perform a sensitivity analysis. We find that particularly a power-law and a negative binomial degree distribution meet the data well and that the tracing probability is rather large. The sensitivity analysis shows no strong dependency on the reproduction number.

Keywords : stochastic SIR model on graph, contact tracing, branching process, parameter inference
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