Statistical Inference for Stochastic Epidemic Models

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We consider continuous-time stochastic compartment models to analyse the within-herd animal infection dynamics. We focus on the estimation of the parameters which can then be used interactively towards more complex model development. We extend the general epidemic model to cases where the Markov property does not hold, by assuming that the infectious periods follow a Weibull distribution, thus allowing for more flexible modelling in many epidemics. Standard statistical techniques for inference in such models are often inappropriate mainly due to the unknown actual infection times, leading to a partially observed transmission process. Inference is also hampered by the highly dependent structure of the data. We propose a Bayesian approach which naturally incorporates the uncertainty in the unobserved infection times, by treating them as unknown quantities to be included in the analysis. We develop a suitably tailored Markov chain Monte Carlo method which allows inferences based on the marginal posterior distributions. The problem of the missing data is reflected on the precision of the estimates, as well as on the convergence performance of our algorithm. However, in epidemic outbreaks, more information is often available in the form of diagnostic test results throughout the course of the epidemic. We show that this additional information improves the quality of the estimates and may also permit more realistic modelling. In that aspect, we also investigate how a diagnostic testing strategy can be adjusted to maximise the benefits in potential statistical conclusions.