On Discretization Algorithms for Stable Quantification and Forecasting of Infectious Disease Magnitudes

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Stable estimation of system parameters for infectious disease outbreaks is of paramount importance to the design of adequate forecasting algorithms [1, 2]. Oftentimes parameter estimation procedures are cast as ODE-constrained nonlinear least squares problems, where infinite dimensional time dependent disease parameters need to be recovered from finite dimensional data sets. As the result, the Jacobian of the corresponding parameter-to-data operator is generally ill-conditioned and may be numerically singular. When such an operator is fitted to noise-contaminated epidemiological data, the estimated parameters tend to be entirely unreliable due to severe error propagation into the approximate solution. The sources of noise in the reported incidence data vary for different types of diseases and can be attributed to possible under or over reporting owing to, for instance, a large proportion of asymptomatic cases or false diagnostics.

In our study we use the Levenberg-Marquardt algorithm to reconstruct a variable transmission rate. The regularization provided by this optimization scheme, which is a penalized version of the Gauss-Newton procedure, is enforced by the appropriate problem-oriented discretization tools. Specifically, we compare what we call parametric and non-parametric discretization routines. By parametric discretization we mean that the transmission rate is modeled by a pre-defined expression that involves only few parameters such as, for example, a declining transmission rate defined by a hyperbolic, harmonic, or exponential function. In a non-parametric discretization scheme the transmission rate is projected onto a subspace spanned by a finite set of orthogonal polynomials, or spline functions. Depending on the nature of the transmission, one may use Legendre or Chebyshev polynomials, B-splines, wavelets, or other base elements. The main goal of our project is to

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References

[1] Chowell G. *Fitting dynamic models to epidemic outbreaks with quantified uncertainty: A Primer for parameter uncertainty, identifiability, and forecasts.* Infect Dis Model, **2**(3):379-398, 2017.

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