State space models as a flexible framework for monitoring epidemics

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To monitor epidemics, different indicators such as incidences, hospitalisation, and deaths play an important rôle. The corresponding data form a multivariate time series whose development over time is governed by several effects: the non-linear reproduction equation describing the spread of the disease, delays due to reporting and the patient-dependent progression of the disease, as well as under-reporting. We show that state space models offer a flexible framework to incorporate these effects. They can easily be fitted even to incomplete data either using an extended Kalman filter or following the likelihood-based approach proposed by Durbin & Koopman [1]. Using publicly available data on COVID-19, we demonstrate how the predicted evolution of states can be used both to monitor the epidemic as well as to generate short-term forecasts.

[1] Durbin, J. and Koopman, S. J. (2001). Time Series Analysis by State Space Methods, Oxford University Press, Oxford.

Biography:
Thomas Hotz is Professor of Probability Theory and Mathematical Statistics at the TU Ilmenau. After his studies at the University of Heidelberg, he worked as a medical statistician at the University of Leicester, UK, and in official statistics at the United Nations Statistics Division, New York, before pursuing his Ph.D. and working as a postdoc at the University of Göttingen's Institute of Mathematical Stochastics under the supervision of Axel Munk. In 2012, he moved to Ilmenau, first as an assistant professor, since 2017 as a full professor. His research interests range from statistics in non-Euclidean spaces to applied statistics, in particular for epidemiology.
Stefan Heyder is a PhD student in applied statistics with Thomas Hotz in Ilmenau. His research interest focuses on developing statistical methods to better understand the spread of infectious diseases, in particular COVID-19. Besides his PhD studentship Stefan also provides statistical consulting services at TU Ilmenau to researchers from a wide variety of disciplines.