AEROSP 567 Final Project Proposal

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I would like to explore how to utilize Particle Markov Chain Monte Carlo to learn time-varying parameters in dynamical systems. Specifically, I would like to review the paper by Joseph Dureau et al and re-construct their modelling on the 2009 A/H1N1 pandemic [1]. The dynamic system to be inferred is the SEIR disease model, for which the system parameter β_t is considered to be time-dependent and needs to be learned.

$$\begin{aligned}
\frac{dS_t}{dt} &= -\beta_t S_t \frac{I_t}{N} \\
\frac{dE_t}{dt} &= \beta_t S_t \frac{I_t}{N} - kE_t \\
\frac{dI_t}{dt} &= kE_t - \gamma I_t \\
\frac{dR_t}{dt} &= \gamma I_t
\end{aligned}$$

As discussed in [1], I will be implementing an adjusted adaptive PMCMC algorithm. PMCMC is briefly outlined in Lecture 25 of the lecture notes [2] and is discussed in details in [3]. I chose this algorithm because I would like to study more about system identification for non-liner systems.

The system model is stated above. The data used in Dureau's paper was derived from official numbers provided by Public Health England during the 2009 pandemic [4], which was a sequence of weekly clinical cases. I would use these same data for re-construction and validation. Then, if time permits, I would also like to find data of similar structure for the COVID-19 pandemic and perform a similar inference.

The outcome of the learning would be the posterior of the trajectories of the effect contact rate, β_t, which is a time-varying system parameter. Personally, the motivation for this project is to learn more about system identification and to implement the Particle Markov Chain Monte Carlo algorithm.

References

[1] J. Dureau, K. Kalogeropoulos, and M. Baguelin, "Capturing the time-varying drivers of an epidemic using stochastic dynamical systems," *Biostatistics*, vol. 14, no. 3, pp. 541–555, 01 2013. [Online]. Available: https://doi.org/10.1093/biostatistics/kxs052

[2] A. Gorodetsky, *AE740 Parameter Inference and State Estimation*, 2019.

[3] C. Andrieu, A. Doucet, and R. Holenstein, "Particle markov chain monte carlo methods," *Journal of the Royal Statistical Society: Series B (Statistical Methodology)*, vol. 72, no. 3, pp. 269–342, 2010. [Online]. Available: https://rss.onlinelibrary.wiley.com/doi/abs/10.1111/j.1467-9868.2009.00736.x

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