IAP PROJECT StUDyS

Université de Liège
– METHODOLOGICAL STATISTICS –

STATISTICS SEMINAR

Jonathan JAEGER
Quantitative methods in social sciences,
Université de Liège

Functional estimation in systems defined by differential equations using Bayesian smoothing methods

Ordinary differential equations (ODEs) are widely used to model physical, chemical and biological processes.

Currently, the most commonly used estimation procedures rely on nonlinear least squares. It uses minimization techniques for the estimation of the ODE parameters and a numerical solver for the approximation of the solution (Biegler *et al.*, 1986). These approaches are computationally intensive and often poorly suited for statistical inference.

Recently, a penalized smoothing method was introduced for parameter estimation and approximation of the solution of systems of differential equations (Ramsay *et al.*, 2007). This approach requires an approximation of the state functions involved in the system of differential equations and a penalty term based on all of these equations. It has solved some of the problems encountered in conventional approaches but suffers from two weaknesses: the selection of the ODE-adhesion parameters is not automatic and the uncertainty measures on the estimation of the ODE parameters must be approximated.

In this talk, the adaption of this ODE-penalized smoothing approach in a Bayesian framework for systems of affine differential equations when the data distribution is homogeneous is presented (Jaeger & Lambert, 2011, 2012a). The two main disadvantages of the frequentist approach are overcome in the Bayesian framework: the selection of the ODE-adhesion parameters is now automatic and the uncertainty measures about parameters can be easily obtained using a sample from the joint posterior distribution. In addition, in this Bayesian approach, prior information about the ODE parameters can be introduced. It manages also in natural way multi-subject studies. Finally, the ODE-adhesion parameters related to each differential equation of the system can be used to validate the proposed dynamic model (Jaeger & Lambert, 2012b). The selection of a dynamic model among several alternatives can be obtained by the comparison of the posterior distributions for these ODE-adhesion parameters.

Friday, November 16, 2012 - 14h00 - Room 0/33 (Building B37)
Rue Grande Traverse 12, 4000 Liege (Parking P32-33)

Info: p.lambert@ulg.ac.be Website: http://www.statsoc.ulg.ac.be/IAP.html

References

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3. J Jaeger and P Lambert. Bayesian penalized smoothing approaches in models specified using affine differential equations with unknown error distributions. Discussion Paper DP2012/17, Institut de Statistique, Biostatistique et Sciences Actuarielles, UCL, 2012a.
4. J Jaeger and P Lambert. On the use of adhesion parameters to validate models specified using systems of affine differential equations. Discussion Paper DP2012/18, Institut de Statistique, Biostatistique et Sciences Actuarielles, UCL, 2012b.
5. J Ramsay, G Hooker, D Campbell, and J Cao. Parameter estimation for differential equations: a generalized smoothing approach. *Journal of the Royal Statistical Society: Series B (Statistical Methodology)*, 69(5):741–796, 2007.