

Robust Bayesian Functional Principal Component Analysis

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Abstract

We develop a robust Bayesian functional principal component analysis (FPCA) by incorporating skew elliptical classes of distributions. The proposed method effectively captures the primary source of variation among curves, even when abnormal observations contaminate the data. We model the observations using skew elliptical distributions by introducing skewness with transformation and conditioning into the multivariate elliptical symmetric distribution. To recast the covariance function, we employ an approximate spectral decomposition. We discuss the selection of prior specifications and provide detailed information on posterior inference, including the forms of the full conditional distributions, choices of hyperparameters, and model selection strategies. Furthermore, we extend our model to accommodate sparse functional data with only a few observations per curve, thereby creating a more general Bayesian framework for FPCA. To assess the performance of our proposed model, we conduct simulation studies comparing it to well-known frequentist methods and conventional Bayesian methods. The results demonstrate that our method outperforms existing approaches in the presence of outliers and performs competitively in outlier-free datasets. Furthermore, we illustrate the effectiveness of our method by applying it to environmental and biological data to identify outlying functional data. The implementation of our proposed method and applications are available at <https://github.com/SFU-Stat-ML/RBFPCA>.

Keywords: Functional data analysis, Robust estimation, Sparse functional data, Multivariate skew elliptical distribution, Outlier detection

Robust Bayesian Analysis

**Bruno Betro, Marek Meczarski, Fabrizio
Ruggeri**

Robust Bayesian Analysis:

Robust Bayesian Analysis David Rios Insua, Fabrizio Ruggeri, 2012-12-06 Robust Bayesian analysis aims at overcoming the traditional objection to Bayesian analysis of its dependence on subjective inputs mainly the prior and the loss Its purpose is the determination of the impact of the inputs to a Bayesian analysis the prior the loss and the model on its output when the inputs range in certain classes If the impact is considerable there is sensitivity and we should attempt to further refine the information the incumbent classes available perhaps through additional constraints on and or obtaining additional data if the impact is not important robustness holds and no further analysis and refinement would be required Robust Bayesian analysis has been widely accepted by Bayesian statisticians for a while it was even a main research topic in the field However to a great extent their impact is yet to be seen in applied settings This volume therefore presents an overview of the current state of robust Bayesian methods and their applications and identifies topics of further interest in the area The papers in the volume are divided into nine parts covering the main aspects of the field The first one provides an overview of Bayesian robustness at a non technical level The paper in Part II concerns foundational aspects and describes decision theoretical axiomatisations leading to the robust Bayesian paradigm motivating reasons for which robust analysis is practically unavoidable within Bayesian analysis *Bayesian Robustness* James O. Berger, 1996 **Robust Bayesian Analysis** J. O. Berger, 1987 Robust Bayesian Analysis Yuanzhang Li, 1990 Robust Bayesian Analysis of Selection Models M. J. Bayarri, J. Berger, 1993 **Robust Bayesian Analysis for Econometrics** Raffaella Giacomini, Toru Kitagawa, Matthew Read, 2021 We review the literature on robust Bayesian analysis as a tool for global sensitivity analysis and for statistical decision making under ambiguity We discuss the methods proposed in the literature including the different ways of constructing the set of priors that are the key input of the robust Bayesian analysis We consider both a general set up for Bayesian statistical decisions and inference and the special case of set identified structural models We provide new results that can be used to derive and compute the set of posterior moments for sensitivity analysis and to compute the optimal statistical decision under multiple priors The paper ends with a self contained discussion of three different approaches to robust Bayesian inference for set identified structural vector autoregressions including details about numerical implementation and an empirical illustration *The Robust Bayesian Analysis of Bayesian Networks* J. Q. Smith, A. R. Daneshkhah, University of Sheffield. Department of Probability and Statistics, 2005 Robust Bayesian Analysis Under Generalized Moments Conditions Bruno Bette, Marek Meczarski, Fabrizio Ruggeri, 1992 **Robust Bayesian Analysis, an Interactive Approach** Brunero Liseo, 1994 Global Robust Bayesian Analysis in Large Models Paul Ho, 2020 **Robust Bayesian Inference when the Data Conflicts with the Prior** Thomas William Lucas, 1991 **Robust Bayesian Analysis of Heavy-tailed Stochastic Volatility Models Using Scale Mixtures of Normal Distributions** C. A. Abanto-Valle, 2008 **Discussion of 'An Overview of Robust Bayesian Analysis' by James Berger** Self Contained: Original Discussion

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