Impact of Autocorrelation on Principal Components and Their Use in Statistical Process Control - DTU Orbit (08/11/2017)

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A basic assumption when using principal component analysis (PCA) for inferential purposes, such as in statistical process control (SPC), is that the data are independent in time. In many industrial processes, frequent sampling and process dynamics make this assumption unrealistic rendering sampled data autocorrelated (serially dependent). PCA can be used to reduce data dimensionality and to simplify multivariate SPC. Although there have been some attempts in the literature to deal with autocorrelated data in PCA, we argue that the impact of autocorrelation on PCA and PCA-based SPC is neither well understood nor properly documented. This article illustrates through simulations the impact of autocorrelation on the descriptive ability of PCA and on the monitoring performance using PCA-based SPC when autocorrelation is ignored. In the simulations, cross-correlated and autocorrelated data are generated using a stationary first-order vector autoregressive model. The results show that the descriptive ability of PCA may be seriously affected by autocorrelation causing a need to incorporate additional principal components to maintain the model's explanatory ability. When all variables have equal coefficients in a diagonal autoregressive coefficient matrix, the descriptive ability is intact, while a significant impact occurs when the variables have different degrees of autocorrelation. We also illustrate that autocorrelation may impact PCA-based SPC and cause lower false alarm rates and delayed shift detection, especially for negative autocorrelation. However, for larger shifts, the impact of autocorrelation seems rather small.

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Authors: Vanhatalo, E. (Ekstern), Kulahci, M. (Intern)
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