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A Robust Multivariate Profile Monitoring Framework

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In classical statistical process monitoring (SPM) applications the Phase I sample is assumed to come from an in-control process, which is however not always valid, especially when the monitoring characteristic for each item/case is a vector of profiles, i.e., a multivariate profile.
The presence of untrustable observations, or, in general, of outliers, especially in high-dimensional settings, can significantly bias and reduce the power of the SPM framework in detecting anomalies.
In particular, when the dimensionality of the data is high, the fraction of perfectly observed cases can be very small, and outliers may occur more realistically in one or a few components only (componentwise), which may be difficult to identify, rather than in all components (casewise). On the other hand, in these cases, down-weighting or eliminating entire observations of multivariate profiles that are contaminated in one or a few components might be unacceptably wasteful.
This research introduces a novel monitoring framework for multivariate functional quality characteristics, named robust multivariate functional control chart (RoMFCC), that is robust to the influence of both functional casewise and componentwise outliers. The RoMFCC framework contains four main elements: a functional filter to detect functional componentwise outliers, a robust imputation of missing components in multivariate functional data, a robust dimension reduction that deals with functional casewise outliers, and a procedure for prospective process monitoring. The performance of the proposed framework is assessed through a wide Monte Carlo simulation also in comparison to competing monitoring schemes that have already appeared in the literature before. The practical applicability of the RoMFCC is demonstrated through a case study in the SPM of a resistance spot welding process in automotive body-in-white manufacturing.
The RoMFCC is implemented in the R package funcharts, openly available on CRAN.

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