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Spatial Rank-Based High-Dimensional Monitoring through Random Projection

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Abstract : High-dimensional process monitoring becomes increasingly important in many application domains, where usually the process distribution is unknown and much more complicated than the normal distribution, and the between-stream correlation can not be neglected. However, since the process dimension is generally much bigger than the reference sample size, most traditional nonparametric multivariate control charts fail in high-dimensional cases due to the curse of dimensionality. Furthermore, when the process goes out of control, the influenced variables are quite sparse compared with the whole dimension, which increases the detection difficulty. Targeting at these issues, this paper proposes a new nonparametric monitoring scheme for high-dimensional processes. This scheme first projects the high-dimensional process into several subprocesses using random projections for dimension reduction. Then, for every subprocess with the dimension much smaller than the reference sample size, a local nonparametric control chart is constructed based on the spatial rank test to detect changes in this subprocess. Finally, the results of all the local charts are fused together for decision. Furthermore, after an out-of-control (OC) alarm is triggered, a diagnostic framework is proposed. using the square-root LASSO. Numerical studies demonstrate that the chart has satisfactory detection power for sparse OC changes and robust performance for non-normally distributed data, The diagnostic framework is also effective to identify truly changed variables. Finally, a real-data example is presented to demonstrate the application of the proposed method.

Keywords : random projection, high-dimensional process control, spatial rank, sequential change detection
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