



## Distribution-Free Phase I Control Charts Based on Multivariate Spatial and Signed Ranks

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The need of distribution-free methods for Phase I analysis has recently received an increasing attention in the statistical process monitoring literature. Some critical issues related to the Phase I analysis of univariate data are even more challenging when several quality characteristics are analyzed simultaneously to assess process stability. Multivariate Shewhart-type control charts, such as the Hotelling's  $T^2$  control chart, are simple to use and effective in detecting both large outliers and sustained shifts in the process parameters. However, the traditional design of these charts relies on the assumption that the underlying process distribution is a multivariate normal. When this assumption is violated or cannot be tested, the chart's signals become questionable. Two distribution-free multivariate control charts for detecting a shift in the location vector of a multivariate process are illustrated. They are based on the multivariate spatial and signed ranks, respectively. In a simulation study, the in-control and out-of-control performance of these distribution-free Phase I control charts are investigated and compared to some existing parametric and nonparametric Phase I methods. The proposed monitoring schemes are able to attain the desired in-control performance for every process distribution, and are also more efficient than their competitors under several out-of-control scenarios and for different shapes of the underlying process distribution.

**Keywords:** Hotelling's  $T^2$ ; Multivariate Signed Ranks; Nonparametric; Spatial Ranks; Statistical Process Control.