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Comparing Xbar Charts: Conventional versus Reweighted Robust Estimation Methods for Univariate Data Sets

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Abstract : Maintaining the quality of manufactured products at a desired level depends on the stability of process dispersion and location parameters and detection of perturbations in these parameters as promptly as possible. Shewhart control chart is the most widely used technique in statistical process monitoring to monitor the quality of products and control process mean and variability. In the application of Xbar control charts, sample standard deviation and sample mean are known to be the most efficient conventional estimators in determining process dispersion and location parameters, respectively, based on the assumption of independent and normally distributed datasets. On the other hand, there is no guarantee that the real-world data would be normally distributed. In the cases of estimated process parameters from Phase I data clouded with outliers, efficiency of traditional estimators is significantly reduced, and performance of Xbar charts are undesirably low, e.g. occasional outliers in the rational subgroups in Phase I data set may considerably affect the sample mean and standard deviation, resulting a serious delay in detection of inferior products in Phase II. For more efficient application of control charts, it is required to use robust estimators against contaminations, which may exist in Phase I. In the current study, we present a simple approach to construct robust Xbar control charts using average distance to the median, Qn-estimator of scale, M-estimator of scale with logistic psi-function in the estimation of process dispersion parameter, and Harrell-Davis qth quantile estimator, Hodge-Lehmann estimator and M-estimator of location with Huber psi-function and logistic psi-function in the estimation of process location parameter. Phase I efficiency of proposed estimators and Phase II performance of Xbar charts constructed from these estimators are compared with the conventional mean and standard deviation statistics both under normality and against diffuse-localized and symmetric-asymmetric contaminations using 50,000 Monte Carlo simulations on MATLAB. Consequently, it is found that robust estimators yield parameter estimates with higher efficiency against all types of contaminations, and Xbar charts constructed using robust estimators have higher power in detecting disturbances, compared to conventional methods. Additionally, utilizing individuals charts to screen outlier subgroups and employing different combination of dispersion and location estimators on subgroups and individual observations are found to improve the performance of Xbar charts.

Keywords : average run length, M-estimators, quality control, robust estimators
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