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An Enhanced Control Chart for Start-Up Processes and Short Runs ⋆

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Abstract

Classic charting procedures are usually designed assuming that process parameters are known or may be estimated using large Phase I samples gathered before a production run. However, in some manufacturing settings, such as during the process start-up, historical data cannot be collected to accurately estimate the in-control process parameters. In this article, we suggest a new self-starting control chart which uses consecutive observations to jointly update the parameter estimates and check for out-of-control conditions. In particular, we introduce a charting procedure, ACUSCORE, that updates the reference pattern of a type-CUSCORE chart using an adaptive EWMA. The proposed control chart seems to outperform traditional self-starting control charts which neglect the dynamic pattern of the mean change.

Key words: Quality Control; Q charts; Recursive Residuals; CUSCORE; Adaptive EWMA.

1 Introduction

Traditional control chart are usually designed assuming that the in-control (IC) process parameters are exactly known. In most practical applications, however, the process parameters are unknown and are replaced with estimates from an IC Phase I sample. Previous research work (see [11] for a systematic review) has demonstrated that parameter estimation substantially degrades the run-length performance of classical control charts. At least in the case of the Shewhart [17], EWMA [14] and CUSUM [15] control charts, using estimates in place of known parameters causes too many false alarms unless the Phase I samples are sufficiently large to accurately estimate the unknown parameters. However, gathering large calibration samples is usually costly and problematic and it may be even impossible in some settings such as during the start-up stages where data are not available before a production run.

In this context, three alternative approaches can be used to address the design issue:

i) modifying decision intervals: control limits of classical control charts are widened to account for the variability in the sampling distribution of the estimates; see for example [13] and [3] for independent and autocorrelated data, respectively;
ii) formulating a proper "change-point" model as suggested in [8], [9], [10]: a chart, based on the likelihood ratio test, is designed without assuming that the in-control process parameters are known;
iii) using "self-starting" control charts ([5], [16], [18], [22], [24], [6]).

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