A side sensitive modified group runs control chart to detect shifts in the process mean

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Gadre and Rattihalli [5] have introduced the Modified Group Runs (MGR) control chart to identify the increases in fraction non-conforming and to detect shifts in the process mean. The MGR chart reduces the out-of-control average time-to-signal (ATS), as compared with most of the well-known control charts. In this article, we develop the Side Sensitive Modified Group Runs (SSMGR) chart to detect shifts in the process mean. With the help of numerical examples, it is illustrated that the SSMGR chart performs better than the Shewhart's X¯ chart, the synthetic chart [12], the Group Runs chart [4], the Side Sensitive Group Runs chart [6], as well as the MGR chart [5]. In some situations it is also superior to the Cumulative Sum chart [9] and the exponentially weighed moving average chart [10]. In the steady state also, its performance is better than the above charts. Keywords: average time-to–signal; CRL chart; EWMA chart; GR chart; MGR chart; SSGR chart; steady-state ATS; synthetic chart

1. Introduction

Globalization has put the industries in a very competitive environment, and the products are expected to be of very high standard. Statistical process control is an effective technique useful to monitor the quality of the product. The quality of the product may depend on one or more characteristics. If it depends on a single quantitative characteristic, a common practice is to use the X¯ chart. Many other efficient control charts have also been discussed in the literature Montgomery [8]. Wu and Spedding [12] proposed the synthetic control chart for detecting small shifts in the process mean by combining Shewhart's X¯ chart and the conforming run length (CRL) chart [1]. In Shewhart's X¯ chart, the observations are assumed to be independent and identically distributed (iid) N(μ, σ2) random variables (rvs) and the disjoint groups of n units are formed. Hence, the group means X¯i(i = 1, 2, . . .) are iid N(μ, σ2/n) rvs. Let μ0 be the target value of the process mean, σ2 the known process variance and δ the shift in the process mean measured in terms of ∗Corresponding author. Email: mpg28@rediffmail.com ISSN 0266-4763 print/ISSN 1360-0532 online DOI: 10.1080/02664760903222190 http://www.informaworld.com

2017 2074 M.P. Gadre et al. the process standard deviation (σ). In the case of the synthetic control chart, a group of n units is declared as non-conforming if X / ¯ ∈ ($\mu 0 - k\sigma/\sqrt{n}$, $\mu 0 + k\sigma/\sqrt{n}$). Furthermore, for $r \geq 1$, Yr (the rth group-based CRL) is defined as the number of conforming groups inspected between the ($r - 1$)th (if one such exists) and the rth non-conforming group including the rth non-conforming group. Then {Yr}∞ r=1 is a sequence of iid geometric rvs with parameter P (the probability that the group being non-conformed). The synthetic chart declares the process as out of control, when for some $r \geq 1$, $Yr \leq Ls$ (the lower control limit of the chart) for the first time. As an illustration, let Ls = 3, Y1 = 4, Y2 = 5 and Y3 = 2. In this case, the synthetic chart gives a signal after observing the third non-conforming group. Here, the suffix 's' for L is used to indicate the synthetic chart. It is to be noted that a signal may be due to a shift in the process mean (a correct signal) or may be due to the chance fluctuation (a false alarm). Therefore, when a signal is received, it is desirable to monitor a process further, to identify the cause for the signal. By considering this fact, Gadre and Rattihalli [4] have proposed the Group Runs (GR) control chart, which is an extension of the synthetic control chart. GR chart declares the process as out of control if $Y1 \leq Lg$ or for some $r > 1$, Yr and Y(r+1) are not exceeding Lg for the first time. Davis and Woodall [3] highlighted an important aspect of side sensitivity and have shown that it can be used to improve the performance of the synthetic chart. In side sensitivity, the sides to which the shifts occur are considered along with the value of the CRL. Gadre and Rattihalli [6] have developed the Side Sensitive Group Runs (SSGR) chart that performs better than the GR chart. The SSGR chart declares the process as out of control if $Y1 \leq Lssg$ (the lower limit of the chart) or for some $r > 1$, $Yr \leq Lssg$, $Y(r+1) \leq Lssg$ and the rth as well as the ($r + 1$)th non-conforming groups indicate shift on the same side of the target value μ0 for the first time. To improve the performance of the process, Gadre and Rattihalli [5] have proposed the Modified Group Runs (MGR) chart that declares the process as out of control if $Y1 \leq L2(mg)$ (the lower limit of the chart) or for some $r > 1$, we have the situation that $Yr \leq L1(mg)$ (the warning limit of the chart) and $Y(r+1) \leq L2(mg)$ for the first time. It is shown that the MGR chart performs better than the SSGR chart. In this article, we propose the Side Sensitive Modified Group Runs (SSMGR) chart to detect a shift in the process mean. It is shown that the proposed chart performs better than the MGR chart. In some situations, it is also superior to the Cumulative Sum (CUSUM) chart and the exponentially weighed moving average (EWMA) chart. In steady state also, the performance of the SSMGR chart is better. The remainder of the paper is organized as follows. The SSMGR chart is discussed in Section 2. The notations required to design the SSMGR chart are explained and the chart is also developed in the same section. Numerical illustrations and the comparison of the SSMGR chart with the other matched compatible variable control charts is carried out in Section 3. Simulation study is also carried out in the same section. In Section 4, we study the steady-state performance of the SSMGR chart. Concluding remarks are included in the last section.