Multi-attribute unit and group runs control chart to identify the process deterioration

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Gadre and Rattihalli [Gadre, M.P. and Rattihalli, R.N., 2005a, A unit and group runs based chart to identify increases in fraction nonconforming. Journal of Quality Technology, 37, 199–209.] proposed a control chart called the unit and group runs (UGR) control chart to identify increases in fraction non-conforming. In this article, the concept of UGR chart is extended to the multi-attribute case to detect the process deterioration. It is illustrated that in multi-attribute cases also, the UGR chart gives a remarkable reduction in out-of-control average time to signal when compared with the multi-attribute np chart, the multi-attribute synthetic chart and the multi-attribute group runs chart recently developed by Gadre and Rattihalli [Gadre, M.P. and Rattihalli, R.N., 2005b, Some group inspection based multiattribute control charts. Economic Quality Control, 20, 191–204.]. The steady state performance of the multi-attribute UGR chart is also excellent. The procedure of identifying the attributes causing signal is also described and illustrated. Keywords: Average time to signal; Bernoulli CUSUM chart; Multi-attribute control chart; Run-length CUSUM chart; Steady state; Synthetic control chart

1. Introduction

Statistical process control (SPC) is a very efficient tool to maintain and uplift the quality of a product. The quality of a product may depend on one or more characteristics and when it depends on a single qualitative characteristic, the np chart is most widely used to monitor the process. Many other attribute control charts were also discussed in the literature (see [1]). Some recently developed and efficient single attribute control charts are Run-Length CUSUM chart [2], Bernoulli CUSUM chart [3], synthetic chart [4], group runs (GR) chart [5] and unit and group runs (UGR) chart [6]. Due to a very high competition in today's world market, it is essential for the producer to take sufficient care to maintain the quality of the product, which can be achieved by considering more than one relevant characteristic.When the characteristics are not necessarily independent, one has to use the multivariate quality control (MQC) techniques, as the univariate control *Corresponding author. Email: mpg28@rediffmail.com Journal of Statistical Computation and Simulation ISSN 0094-9655 print/ISSN 1563-5163 online http://www.tandf.co.uk/journals DOI: 10.1080/00949650701323657

[The University of Pune] at 03:08 30 October 2015 1000 M. P. Gadre and R. N. Rattihalli charts are incapable to incorporate the interdependency between the characteristics. Lowery and Montgomery [7] have shown that to monitor a multivariate process, MQC procedure is more sensitive than that of a procedure based on univariate control charts. Due to advancement in technology, many characteristics can be assessed simultaneously, and as such, the MQC techniques have become much popular. Many control charts, such as multivariate CUSUM chart (for a review, one may refer ref. [7]) and multivariate exponentially weighted moving average (EWMA) chart [8], have been developed in the last two decades. All these charts are related to multivariate variable processes. However, in some production processes, the counts related data are sufficient (see [9]). A process based on the count related multi-characteristic data be referred as a multivariate attribute process. Some developed techniques are multi-attribute np (MNP) chart [10] and Jolayemi's multi-attribute control chart (MACC) [11]. These MACCs are based on some type of approximations. Gadre and Rattihalli [12] developed exact MACC (E-MACC) by using the exact joint distribution and the most powerful (MP) test. The implementation of this chart is similar to that of np chart. In E-MACC, the status of the process is determined on the basis of the status of a group of fixed size (n, say). In the case of single attribute, Gadre and Rattihalli [6] illustrated that the UGR chart performs remarkably better than any other existing single attribute control chart. Recently, Gadre and Rattihalli [13] developed the multi-attribute np (MA-np) chart, the multi-attribute synthetic (MA-Syn) chart and the multi-attribute Group Runs (MA-GR) chart. It was numerically illustrated that MA-GR chart performs better than MA-np and MA-Syn charts. As in the case of single attribute, UGR chart performs remarkably better than any other single attribute control chart and the same can be expected in multi-attribute case also. In this article, we develop the multi-attribute UGR (MA-UGR) chart and illustrate that MA-UGR chart performs uniformly better than the matched MA-np, MA-Syn and MA-GR charts to identify the process deterioration. Remainder of the paper is organized as follows. Some preliminaries are discussed in section 2. Section 3 includes numerical illustrations and the comparison of the MA-UGR chart with others in zero as well as in steady state. When MACC gives a signal, it just indicates that the process has gone out of control, but it does not readily identify the attributes causing the signal. Therefore, in section 4, a procedure to identify the attributes responsible for a signal is described and the same is illustrated. The concluding remarks are included in section 5.