Distribution-free profile monitoring schemes

Ching-Ren Cheng and Jyh-Jen Horng Shiau* (洪志真)
Institute of Statistics, National Chiao Tung University

Abstract

Profile monitoring has been a growing and promising area of research in statistical process control (SPC) in recent years. At the same time, nonparametric or distribution-free methodologies have become important tools in SPC because the underlying distribution of process data is often unavailable in real applications. In this study, we develop Phase I and II distribution-free monitoring schemes for nonlinear profiles with random effects. The technique of principal component analysis (PCA) is utilized to analyze the variance-covariance structure of the in-control profiles. Through eigen-analysis, the profile data space is decomposed into two subspaces: (i) the "in-control" eigen-space, which is defined as the space spanned by the first few principal components (PCs); and (ii) the corresponding orthogonal complementary space spanned by the rest of the PCs. Then two Hotelling T^2 statistics based on the PC scores obtained from projecting the profile data to the principal components of the two eigen-spaces can be used for process monitoring. We propose applying multivariate distribution-free monitoring schemes to the random vector composed of the two T^2 statistics to construct distribution-free control charts for the profiles. Distribution-free methods based on spatial signs are considered in this study. Simulation results show that the proposed methods are effective in detecting changes in the location and the scatter matrix of the process distribution. The applicability of the proposed methods is demonstrated with an actual data set.