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Adaptive Process Monitoring for Time-Varying Situations Using Statistical Learning Algorithms

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Abstract : Statistical process control (SPC) is a practical and effective method for quality control. The most important and widely used technique in SPC is a control chart. The main goal of a control chart is to detect any assignable changes that affect the quality output. Most conventional control charts, such as Hotelling's T2 charts, are commonly based on the assumption that the quality characteristics follow a multivariate normal distribution. However, in modern complicated manufacturing systems, appropriate control chart techniques that can efficiently handle the nonnormal processes are required. To overcome the shortcomings of conventional control charts for nonnormal processes, several methods have been proposed to combine statistical learning algorithms and multivariate control charts. Statistical learning-based control charts, such as support vector data description (SVDD)-based charts, k-nearest neighbors-based charts, have proven their improved performance in nonnormal situations compared to that of the T2 chart. Beside the nonnormal property, time-varying operations are also quite common in real manufacturing fields because of various factors such as product and set-point changes, seasonal variations, catalyst degradation, and sensor drifting. However, traditional control charts cannot accommodate future condition changes of the process because they are formulated based on the data information recorded in the early stage of the process. In the present paper, we propose a SVDD algorithm-based control chart, which is capable of adaptively monitoring time-varying and nonnormal processes. We reformulated the SVDD algorithm into a time-adaptive SVDD algorithm by adding a weighting factor that reflects time-varying situations. Moreover, we defined the updating region for the efficient model-updating structure of the control chart. The proposed control chart simultaneously allows efficient model updates and timely detection of out-of-control signals. The effectiveness and applicability of the proposed chart were demonstrated through experiments with the simulated data and the real data from the metal frame process in mobile device manufacturing.

Keywords : multivariate control chart, nonparametric method, support vector data description, time-varying process
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