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A novel fault detection and diagnosis approach based on orthogonal autoencoders

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The need to analyze complex nonlinear data coming from industrial production settings is fostering the use of deep learning algorithms in Statistical Process Control (SPC) schemes. In this work, a new SPC framework based on orthogonal autoencoders (OAEs) is proposed. A regularized loss function ensures the invertibility of the covariance matrix when computing the Hotelling T^2 statistic and non-parametric upper control limits are obtained from a kernel density estimation. When an out-of-control situation is detected, we propose an adaptation of the integrated gradients method to perform a fault contribution analysis by interpreting the bottleneck of the network. The performance of the proposed method is compared with traditional approaches like principal component analysis (PCA) and Kernel PCA (KPCA). In the analysis, we examine how the detection performances are affected by changes in the dimensionality of the latent space. Determining the right dimensionality is a challenging problem in SPC since the models are usually trained on phase I data solely, with little to no prior knowledge on the true latent structure of the underlying process. Moreover, data containing faults is quite scarce in industrial settings, reducing the possibility to perform a thorough investigation on the detection performances for different numbers of extracted features. The results show how OAEs offer robust results despite radical changes in the latent dimension while the detection performances of traditional methods witness significant fluctuations.

Keywords

Statistical Process Control; Autoencoders; Fault Detection and Diagnosis

Special/invited session

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