Detecting Covariance Shifts in Multichannel Profiles

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Modern industrial systems generate multichannel profile data continuously, requiring effective real-time monitoring and fault diagnosis. While many existing methods prioritize detecting shifts in the process mean, changes in the covariance structure are just as important, as they reflect the dynamic interdependencies among multiple variables. This study introduces a functional graphical modeling framework to represent conditional dependencies in multichannel profile data, addressing challenges posed by high dimensionality and sparsity. The method leverages penalized likelihood ratio tests with adaptive penalty terms to detect a wide range of covariance structure changes. To enhance interpretability, a diagnostic procedure based on change-point detection is used to pinpoint the specific relationships that have changed. Simulation studies and a case study on multichannel temperature profile monitoring demonstrate the superior performance of the proposed approach compared to existing methods.

Keywords: Profile Monitoring, Statistical Process Control, Functional Graphical Models, Multichannel Profiles

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