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Leveraging Machine Learning and Process Monitoring for Real-Time Data Stream Surveillance

Real-time monitoring systems play a crucial role in detecting and responding to changes and anomalies across diverse fields such as industrial automation, finance, healthcare, cybersecurity, and environmental sensing. Central to many of these applications is multivariate statistical process monitoring (MSPM), which enables the concurrent analysis of multiple interrelated data streams to identify subtle shifts in system behavior. Such systems require models that can handle high-speed data streams, deliver rapid insights, and adapt effectively to evolving conditions.

This study provides an extensive review of statistical and machine learning techniques used in real-time monitoring, with a special focus on MSPM methods and their integration with online and streaming data analysis. We classify these approaches into traditional statistical frameworks, including MSPM, online and streaming machine learning models, and deep learning-based architectures, highlighting their suitability for different monitoring contexts. Furthermore, we address system-level aspects such as edge computing, distributed architectures, and streaming data platforms.

By critically examining existing methods, we reveal current challenges, including managing concept drift, improving interpretability, and overcoming computational limitations, while outlining promising avenues for future investigation. This article aims to serve as both a comprehensive resource and a practical guide for researchers and practitioners developing intelligent real-time monitoring solutions.

Special/ Invited session

Classification

Mainly application

Keywords

Machine learning;Multivariate statistical process Monitoring;Statistical process control

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Track Classification: Machine Learning