Abstract

Advanced Fault Detection (FD) and isolation schemes are necessary to realize the required levels of reliability and availability and to minimize financial losses against failures. In particular, FD is essential in modern Wind Turbine Systems (WTSs) which are designed to generate electrical energy as efficiently and reliably as possible. This paper presents a practical FD framework using data-driven methods. The main objective is the early detectionof involuntary abnormalities of various types and locations. Conventional methods are based on the exact model and/or signal patterns or hardware redundancy and they generally fail to address this issue. Alternatively, the presented algorithm is motivated by the availability of fast sensors and powerful computers yielding big data which can be explored to extract and exploit useful information. In a typical WTS, FD procedures face particular challenges attributed to high levels of measurement noise and sparse changes due to the fast dynamics as well as switching control and transients. In this scope, a minimum informative set of measured variables is proposed to describe accurately and completely the system behaviour under all operating conditions. Among data-based strategies, univariate and multivariate statistical analysis tools are recommended for this approach. Principal Component Analysis(PCA) is used in this paper for its distinguished capabilities of dimensionality reduction, features de-correlation, and noise rejection. Multi PCA models are trained as a statistical reference reflecting the data variability in local zones and used in parallel for online FD. An adaptive threshold scheme, based on a modified EWMA control chart, is also used to efficiently evaluate the resulting residuals, so the overall algorithm is robust to outliers and sensitive to small and sudden abnormalities. Static and dynamic applications are investigated for FD in modern WTSs under different operation zones. The considered abnormalities span faults having different levels of severity and range from sensors and actuators to system faults. Compared to existing methods in the literature, the proposed framework demonstrates potential applications with a broader utilization scope and promising performance.