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”COMO2#4 - The design of optimal indicators for early fault detection using a generalized likelihood ratio test”

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This study elaborates on a methodology to design health indicators for vibration-based condition monitoring of rotating machines for early fault detection. These indicators are optimal in maximizing the probability of detection given a constant rate of false alarms. Two probability density functions (PDF) modeling the vibration signals' healthy and faulty states are exploited to generate health indicators using a generalized likelihood ratio test. The key point is formulating a framework to express the health indicators as the function of the partial derivatives of the PDF of the healthy state and a modulation function. The modulation function allows the detection of slight deviations from the healthy state of the vibration signals. Furthermore, it is shown that specific choices of the modulation functions recover conventional health indicators such as kurtosis, skewness, Lp/Lq-norms, the negentropy of the squared envelope, etc. Since the indicators are asymptotically distributed as a chi-squared distribution, a statistical threshold can be estimated to assess the machine's state with respect to its healthy state. The proposed approach is formulated in this study in detail. The performance of the thresholds is demonstrated on simulated and experimental vibration signals. It is shown that the transition from the healthy to the faulty state of the machine can be detected via the threshold. An important conclusion of this study is that many conventional health indicators are optimal if and only if the healthy state of the machines is Gaussian. The proposed methodology shows how to design indicators for non-Gaussian descriptions of the healthy state and can pave the way for the development of many other health indicators by carefully selecting the PDF of the healthy state and the modulation function.

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