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Monitoring based on time-frequency tracking of estimated harmonic series and modulation sidebands

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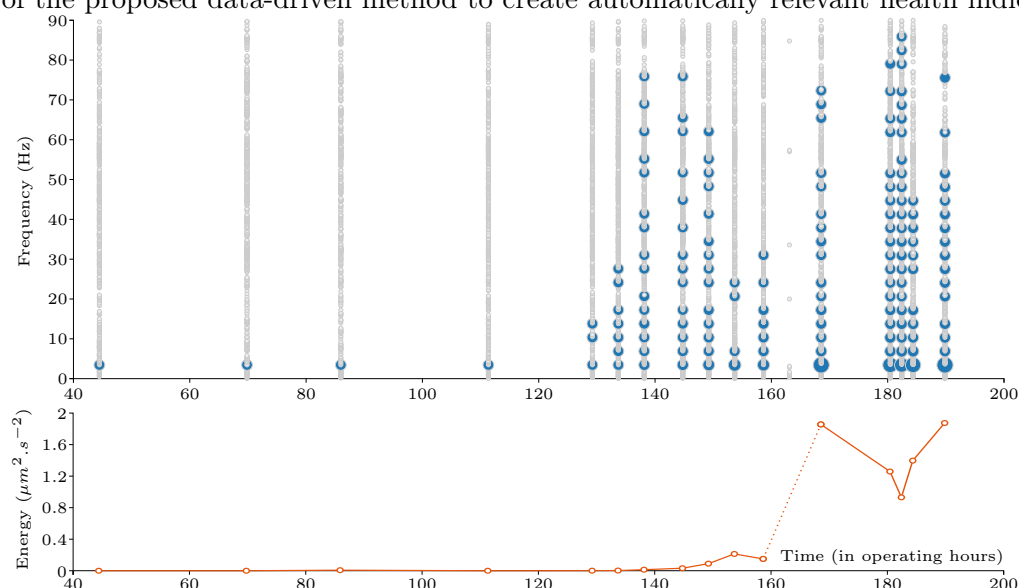
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The installation of a Condition Monitoring System (CMS) on a mechanical machine (e.g., on a wind turbine) aims to reduce the operating costs by applying a predictive maintenance strategy. The CMS is composed of sensors acquiring signals from which system health indicators are computed and monitored. Part of those indicators are predefined depending on the monitored system kinematic and are computed by averaging large or narrow spectral bands. The averaging and the need for predefined thresholds for default detection may induce lots of false alarms while reducing the ability to detect the default early.

To get precise health indicators reflecting each local meaningful spectral content, the AStrion software proposes a new data-driven monitoring strategy without any *a priori* on the measured signals. First, an automatic spectral analysis is applied to detect, characterize and classify the different spectral structures of the successive measured signals. These spectral structures can be either single spectral peaks, either peaks grouped in harmonic series or in modulation sidebands [1]. Second, these spectral structures are characterized by several features, including for example the number of peaks, the characteristic frequencies and the energy. This gives a snapshot of the system health at the signal acquisition time.

To perform an automatic diagnosis of the system, the spectral evolution should be tracked along the time snapshots. In this paper, we propose a time tracking method based on McAulay & Quatieri algorithm [2] which has been designed originally for speech signals acquired on a continuous temporal basis. We have adapted [2] in order to account not only for single spectral peak evolution but also for the evolution of more complex structures such as harmonic series or modulation sidebands, even in the case of signals acquired on a non-regular temporal basis, as it is often the case. Moreover, an added sleep state makes the proposed method robust against non-detected spectral structures at a given time. Finally, the temporal evolution of the spectral structure features can be monitored and used as precise health indicators.

The following figure is a result of the proposed method applied on real signals coming from a test bench designed in [KAstrion project](#) for simulating a wind turbine operation and for which the inner race of the main bearing has been damaged. Above, the time frequency map displays a zoom of the spectral peaks detected (around 20.000 per snapshot, represented by circles) and shows in blue the tracking from 44 to 189 operating hours of a spectral peak at 3.45 Hz. This particular peak evolves at 129 hours to become an harmonic series with more and more peaks and energy. Its energy evolution (plotted below) shows an increase which mirrors out a failure. In a following step [3], this spectral structure has been associated with the ball pass frequency of the inner ring of the main bearing. A dismantling of this bearing has confirmed the failure. This result shows the potential of the proposed data-driven method to create automatically relevant health indicators.



References

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