Comparison and Improvement of Techniques for Transmission-Path Restoring

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Keywords: vibration signal, transmission-path, pre-whitening, adaptive clutter separation (ACS), Cepstrum-liftering, AR model, restoration process.

Abstract:

Condition based monitoring by vibration sensors is a widely spread technique for monitoring the status and condition ("health") of rotating machines. In most cases, the monitoring is based on the ability to isolate specific elements of the vibration signals, generated by the different rotating components.

The generated signals are propagating through various transmissions paths of the machine, that distort the original signals, hence affect the assessment of the machine's condition. While these effects are usually ignored by most vibration analysis techniques, first steps towards mitigating this problem have been taken place during the last years. These techniques used pre-whitening methods, which usually served to separate the signal from its background, as well as to reduce the transmission path effects.

In this study, we aim to go a step further in transmission path restoring through deepening our understanding of their effects on the vibration signals. We start by reviewing three main pre-whitening methods: liftering low quefrencies at the Cepstrum (Cepstrum-liftering), adaptive clutter separation (ACS), and pre-whitening using auto-regressive (AR) models.

We first show that signal's pre-whitening by the AR model has large errors and therefore is less adequate for transmission path restoration processes. Through several simulations, we show that the AR model succeeds in extracting the background spectrum only where the noise is significantly larger than any other component in the PSD. For all other cases, there are large inaccuracies at the restoring background process. We propose a theoretical explanation for this phenomenon, and then strengthen our argument that AR in its current use is less adequate for this purpose.

We then propose a theoretical approach to adjust parameters for ACS and Cepstrum-liftering techniques and examine them and their sensitivity through quantitative methods. By tying the theoretical adequate windows parameters of Cepstrum-liftering and ACS, we show that it is possible to predict the sizes of these two adequate windows. Furthermore, we suggest an adaptive algorithm that is based on the theoretical calculation to reach more accurate values for the parameters of the window in real cases.

After adjustment of the parameters, we compare ACS and Cepstrum-liftering through a variety of simulations and receive slightly different quantities results of the transmission path estimation using ACS and Cepstrum liftering than the former paper [1].

A new technique to restore the transmission path background and its phase is proposed (Figure 1). The restoration of the phase is an important feature due to its deep implications on the ability to correctly restore the original signal in the time domain. The new technique is based on AR model and artificial noise colorization to restore both the background spectrum and its phase. Furthermore, it also improves the magnitude of the restored background, compared to ACS and Cepstrum-liftering techniques.

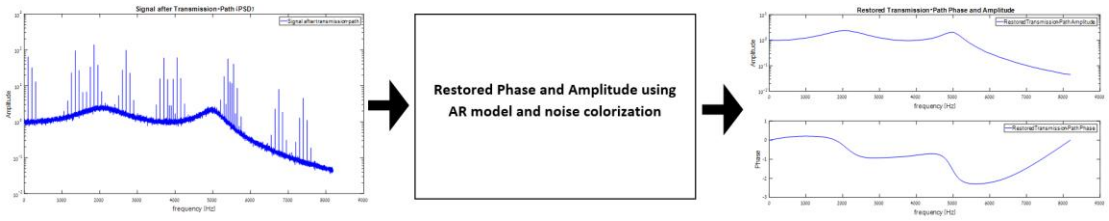

Figure 1 – restored Transmission-Path phase and amplitude

We also suggest exploiting the advantage of the new technique to restore the background in the frequency domain by converting the signal to the order domain and restore it there. The technique is highly beneficial in cases where the signal is smeared in the frequency domain but is sharp in the order domain, cases which the system rotating speed varies during the time.

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