Delamination Damage Detection of Concrete Bridge Decks using Enhanced Acoustic NDE

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Introduction

Delamination of concrete above the upper reinforcing bars is a common problem in bridge decks. The detection of delamination is important for bridge maintenance and acoustic non-destructive evaluation (NDE) is widely used due to its low cost, speed and ease of implementation. In these approaches, the inspector sounds the surface of the deck using a hammer or bar and assesses delamination by the "hollowness" of the sound [1]. However, these tests are typically performed in a noisy environment and noise needs to be removed for successful detection.

Noise Cancelling Algorithms

Commonly used noise cancelling algorithms such as the least mean square adaptive filter (LMS) [2] and traditional independent component analysis (ICA) [3] do not work well on field recordings, as the assumptions behind these algorithms cannot be guaranteed. In this paper, a modified ICA [4] is used to extract the signal of interest from a convolutive mixture of signal and noise. In this algorithm, delayed versions of recordings from multiple microphones are de-mixed using traditional ICA. The independent components (ICs) thus obtained are delayed and scaled version of the original sources. These ICs are grouped into 2 groups based on similarity. Subsequently, the original signal can be reconstructed by applying the inverse of the process described above. This method can be used to separate both linear and convolutive mixtures. The computation speed is also high (a necessity for real time processing). The performance of the modified ICA is shown in Figure 1.

Detection Algorithm

Mel-frequency cepstral coefficients (MFCCs) [5] of the reconstructed signal from the modified ICA were extracted and used for delamination detection. A linear classifier [6] was trained and used for delamination detection. The performance of the proposed method was verified by tests under different noise levels. The results show that the rate of error (misclassification) increases from 1.44% (clean signal) to 48.49% (noisy signals) if the recordings are used directly. The modified ICA reduces the error rate for the noisy signal to only 1.71%.

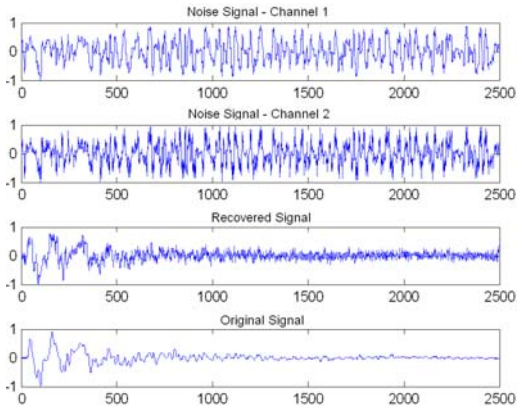

Figure 1. Performance of Modified ICA

Conclusions

This paper presents a method to detect bridge-deck delamination using enhanced acoustic NDE signals. The results show that the introduction of a noise cancelling algorithm greatly increases the robustness of the system. The accuracy of the complete system is high and suitable for field use.

References

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