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Abstract

On the Implementation of Downsampling Permutation Entropy Variants in the Detection of Bearing Faults in Rotatory Machines †

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Background: The Multiscale Permutation Entropy (MPE) is a powerful tool in the differentiation of physiological electrical activity. In particular, the literature has found a clear link between the presence of faults in rotatory machines signals (Zheng 2018), and a reduction in Entropy within them. Therefore, any improvement in the precision of the MPE estimation enhances the chances of detecting increasingly nuanced changes in fault detection.

Objectives: In the present work, we first provide an alternative Permutation Entropy approach: the Refined Composite Downsampling Multiscale Permutation Entropy (rcDPE), which further reduces the variance over Refined Composite Multiscale Permutation Entropy (rcMPE) [Humeau-Heutier, 2015], by applying an alternative to the widely used coarse-graining procedure for multiscaling.

Methodology: Using the Bechhoffer bearing fault dataset (2013), we performed a 3-way ANOVA test with the following factors: Type of signal (presence of faults), Method, and Dimension. We also found the optimal parameters in this dataset in order to increase the entropy difference between faulty and non-faulty components.

Results: From the ANOVA test, we found all factors and interactions to be statistically significant (p0.001). Furthermore we found that, albeit rcDPE greatly reduces the variance in PE measurements, the difference between Type of signal is reduced due to aliasing effects. The best performance is achieved with the use of an anti-aliasing filter in conjunction with rcDPE. For this particular dataset, classification between Types is reduced with increased Dimension, where only the filtered rcDPE remains significant. Therefore, rcDPE presents an important alternative in the exploration of Complexity-based classification techniques, capable of discerning more subtle changes between fatigued and non-fatigued muscle contractions.