Machine Learning Classification of Cohen's Class Time-Frequency Representations of Non-Stationary Signals: Effects on Earthquake Detection

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The analysis of non-stationary signals is often performed on raw waveform data or on Fourier transformations of those data, i.e., spectrograms. However, the possibility of alternative time-frequency representations being more informative than spectrograms or the original data remains unstudied. In this study, we tested if alternative time-frequency representations could be more informative for machine learning classification of seismic signals. This hypothesis was assessed by training three well-established convolutional neural networks, using nine different time-frequency representations, to classify seismic waveforms as earthquake or noise. The signals used in the experiment were seismogram instances from the LEN-DB seismological dataset (Magrini et al. 2020). The results demonstrate that Pseudo Wigner-Ville and Wigner-Ville time-frequency representations yield significantly better results than the base model, while Margenau-Hill performs significantly worse (P < .01). Interestingly, the spectrogram, which is often used in non-stationary signal analysis, did not yield statistically significant improvements. This research could have a notable impact in the field of seismology because the data that were previously hidden in the seismic noise are now classified more accurately. Moreover, the results might suggest that alternative time-frequency representations could be used in other fields which use non-stationary time series to extract more valuable information from the original data. The potential fields encompass different fields of geophysics, speech recognition, EEG and ECG signals, gravitational waves and so on. This, however, requires further research.