Machine learning DAS signal denoising without clean ground-truth signals

Sacha Lapins*†[1], Antony Butcher[1], J-Michael Kendall[2], Thomas Hudson[2], Maximilian Werner[1], and Anna Stork[3]

[1]University of Bristol – United Kingdom
[2]Oxford University – United Kingdom
[3]Silixa – United Kingdom

Abstract

We present a weakly supervised machine learning (ML) method for suppressing strong random noise in distributed acoustic sensing (DAS) recordings. The method aims to map random noise processes to a chosen summary statistic, such as the distribution mean, median or mode, whilst retaining the true underlying signal. The dataset used is a DAS array deployed at the surface of the Rutford Ice Stream in Antarctica. Despite being a very low anthropogenic noise environment, strong random noise processes, such as weather-induced instrument noise, heavily dominate the signal from microseismic icequake events. Here, we demonstrate that the proposed method greatly suppresses incoherent noise and enhances the signal-to-noise ratios (SNR) of microseismic events, enhancing the performance of subsequent processing steps, such as event detection. Our best performing model for this task is extremely lightweight by deep learning standards (three hidden layers, 47,330 model parameters), processing 30 secs data recorded at a sample rate of 1000 Hz over 985 channels (_˜ 1 km of fibre) in < 0.3 secs. Furthermore, it is trained in a 'weakly supervised' manner, such that it requires no manually-produced labels (i.e., pre-determined examples of clean event signals or sections of noise) for training. Lastly, our GPU-optimised Tensorflow implementation is considerably faster than standard Python filtering routines, such as bandpass filtering using the open-source obspy framework, and doesn't require any prior assumptions on the distribution of the noise or event signals, unlike traditional spectral methods. We argue that efficient data-driven denoising methods, such as the one presented, will prove essential to time-critical DAS detection and early warning processing workflows, particularly in the case of microseismic monitoring.

*Speaker
†Corresponding author: sacha.lapins@bristol.ac.uk