The implementation of a variable smoothening factor in the minimum noise estimator

As samples are subsampled in signal processing software continuously streaming data from the environment (or through simulation), these samples of a defined length constitute a frame of size equivalent to the length of the samples. For the implementation of the noise floor estimator on a test audio signal of sample rate 48000 samples per second we used a sample window of 0.2 seconds or equivalently (0.2 48000) samples. The estimation procedure includes smoothening the PSD samples by a factor (fixed or variable) and then estimating the noise floor from the minimum values of the smoothened PSD samples (called periodogram) based by a certain value in other to have an unbiased noise floor estimate. Fixed smoothening factor is good but does not put to account the varying changes in the subsampled samples (presence and absence of signal) so all signal samples are smoothen by the same factor, however it will be optimum if the smoothening factor could sense the presence and absence of signal and the vary the smoothening factor to suit the PSD samples state. But how do we implement this? Consider the smoothening relation given below.

Where is the smoothened PSD samples, is the smoothening factor and is the FFT samples of the subsampled streaming data at an arbitrary sample rate. As the smoothened relation is supposed to estimate the noise in the signal, an optimum choice of will be the reduction of the mean square error between the smoothened PSD (periodogram) samples and the true noise, . So, with mathematical simplification our (for optimum smoothening factor) becomes = 0 which turns out as .

Well, we have got our variable smoothening factor but it depends on the true noise, , which is what we want to estimate. So, again we need to compromise by replacing the true noise with the estimated noise, and adjust the variable smoothening factor with a correction factor to track the error introduced. This compromise entails a characteristics and a recursive relation which was empirically determined.

The recursive relation is given as and x in the bounded characteristics (bounded by 1) is which implies that the bounded characteristics is determined from the ratio of the estimated and true PSD of the subsampled signal.

Bias of Minimum statistics noise estimator

Considering that the noise power/floor is estimated by the minimum value of a set of samples (3 out of 8 samples) we are sure to get a biased output/noise power, as the value of the noise power is lesser than the mean of the set of correlated PSD samples. To solve this deviation we introduce a bias, which is also the inverse mean of the set of estimated PSD samples. Note that the estimated PSD samples is the smoothened PSD samples from a set of subsampled samples. Big question is, ‘Why the term inverse mean’? Well, here is the story, the estimated PSD samples has a mean proportional to the noise power and the variance is also proportional to the square of noise power which is . As the minimum PSD samples which represents the noise floor/power is derived from the smoothened PSD samples, its mean is also proportional to the and the variance is as well proportional to . We will denote these statements as , ,

and respectively. However, we will define the bias as the factor or value whose inverse is bounded by 1 such that is the mean of the minimum statistics noise estimate of D correlated samples at a true noise power of 1 which is defined as . Hence it is the inverse of the mean which depends on the length of correlated PSD samples considered, D. However, that is not all the dependencies of the bias. Recall that the minimum noise estimate is the set of samples derived from the PSD estimate (smoothened PSD samples) so the variance (normalized variance , ) will have some effect on the value of the bias (some bounding effect) and we denote the second dependent factor as (called the equivalent degree of freedom). Some plots of against and will explain better the term degree of freedom.

After this great discussion what is our estimated noise power, it is where is the correcting factor given as , is the bias or inverse mean and is the minimum PSD sample. More details concerning the algorithm, equation, derivation and others can be found in the journal *“Noise Power Spectral Density Estimation Based on Minimum Statistics”.*

I am currently working on the API, please send your corrections and suggestions to my email [*ogechukwukanu@gmail.com*](mailto:ogechukwukanu@gmail.com)as it will be most appreciated.