

Introduction to Adaptive Noise Cancellation

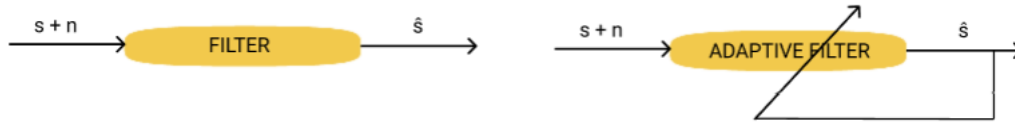
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I. Filtering

You can imagine a filter as a black box (yellow in the pictures) which may have multiple inputs and outputs. In noise cancellation we will deal with filter with signal input/output.

Our filter has an input signal $s + \nu$ and its goal is to construct an output signal \tilde{s} , in a way that is valid: $s \approx \tilde{s}$.

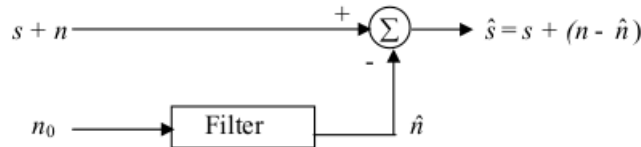
Adaptive filters also use their output as feedback in order to adapt their characteristics.



II. Noise Cancellation

Noise Cancellation is a variation of optimal filtering that involves producing an estimate of the noise by filtering the reference input and then subtracting this noise estimate from the primary input containing both signal and noise.

It makes use of an auxiliary or reference input which contains a correlated estimate of the noise to be cancelled. The reference can be obtained by placing one or more sensors in the noise field where the signal is absent or its strength is weak enough. Subtracting noise from a received signal involves the risk of distorting the signal and if done improperly, it may lead to an increase in the noise level. This requires that the noise estimate \tilde{n} should be an exact replica of n . If it were possible to know the relationship between n and \tilde{n} , or the characteristics of the channels transmitting noise from the noise source to the primary and reference inputs are known, it would be possible to make \tilde{n} a close estimate of n by designing a fixed filter. However, since the characteristics of the transmission paths are not known and are unpredictable, filtering and subtraction are controlled by an adaptive process. Hence an adaptive filter is used that is capable of adjusting its impulse response to minimize an error signal, which is dependent on the filter output. The adjustment of the filter weights, and hence the impulse response, is governed by an adaptive algorithm. With adaptive control, noise reduction can be accomplished with little risk of distorting the signal. Infact, Adaptive Noise Canceling makes possible attainment of noise rejection levels that are difficult or impossible to achieve by direct filtering.



The error signal to be used depends on the application. The criteria to be used may be the minimization of the mean square error, the temporal average of the least squares error etc. Different algorithms are used for each of the minimization criteria e.g. the Least Mean Squares (LMS) algorithm, the Recursive Least Squares (RLS) algorithm etc.