Adaptive Interference (Noise) Cancellation*

Douglas L. Jones

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Abstract

Adaptive interference (or noise) cancellers are widely used. An adaptive noise canceller adaptively filters a noise reference input to maximally match and subtract out noise or interference from the primary (signal plus noise) input.

NOTE: Automatically eliminate unwanted interference in a signal.



Figure 1

The object is to subtract out as much of the noise as possible.

Example 1: Engine noise cancellation in automobiles

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Figure 2

The firewall attenuates and filters the noise reaching the listener's ear, so it is not the same as n'_k . There is also a delay due to acoustic propagation in the air. For maximal cancellation, an adaptive filter is thus needed to make n'_k as similar as possible to the delayed n_k .



Figure 3

Exercise 1

What conditions must we impose upon the microphone locations for this to work? (Think causality and physics!)

1 Analysis of the interference cancellor





$$E[\epsilon_k^2] = E[(s_k + n_k - y_k)^2] = E[s_k^2] + 2E[s_k(n_k - y_k)] + E[(n_k - y_k)^2]$$

We assume s_k , n_k , and n'_k are zero-mean signals, and that s_k is independent of n_k and n'_k . Then

$$E[s_k(n_k - y_k)] = E[s_k] E[n_k - y_k] = 0$$

$$E\left[\epsilon_{k}^{2}\right] = E\left[s_{k}^{2}\right] + E\left[\left(n_{k} - y_{k}\right)^{2}\right]$$

Since the input signal has no information about s_k in it, minimizing $E\left[\epsilon_k^2\right]$ can only affect the second term, which is the standard Wiener filtering problem, with solution

$$W = R_{n'n'}^{-1} P_{nn'}$$