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6 Adaptive Interference Canceling

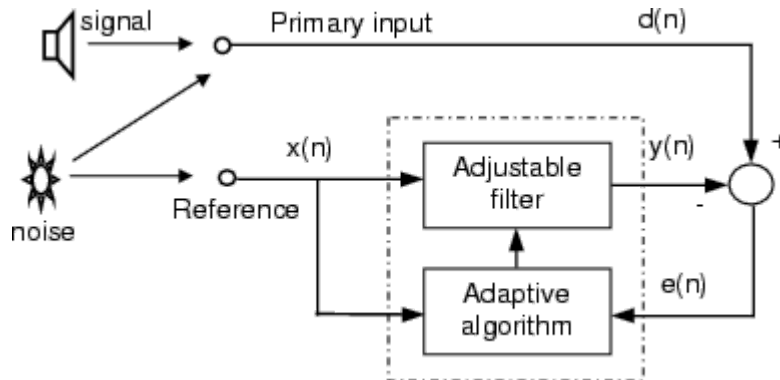


Figure 2.17: Block diagram of the adaptive interference canceling setup.

Several practical applications of adaptive filters such as active noise and vibration control, beam forming, and echo cancellation fall under the category of adaptive interference canceling. The basic principle of adaptive interference canceling is shown in Fig. 2.17 [11]. In all interference canceling application, a useful signal is corrupted with uncorrelated interference and it is desired to recover the signal from the observed corrupted signal. Adaptive interference cancelers rely on using two separate sensors. The first sensor is referred to as the primary input and receive a combination of signal and interference ($d(n) = s(n) + x1(n)$), where $s(n)$ is the signal generated by the signal source and transmitted through the channel between the source and the primary sensor, and $x1(n)$ is the interference at the primary sensor. The second sensor, referred to as the reference input, receives an interference $x(n)$ which is correlated with $x1(n)$ in some sense but uncorrelated with $s(n)$. The reference interference $x(n)$ is filtered by an adaptive filter to produce the filter output $y(n)$. The adaptive filter coefficients are adjusted so that $y(n)$ is as close as possible to the interference at the primary sensor $x1(n)$. The recovered signal is then the adaptive filter error $e(n) = d(n) - y(n)$. The above principle can readily be extended to cancel multiple unwanted interferences by simply adding one extra reference branch for each interfering signal. Each reference branch includes a sensor that receives a signal correlated with one interference and uncorrelated with the useful signal. The output of each reference sensor is filtered by an adaptive filter. The outputs of all adaptive filters are added together to form the estimation of all interferences. This estimate is subsequently subtracted from the corrupted signal to produce the clean signal. A frequently mentioned application of adaptive interference canceling is cleaning power-line interference from weak sensor signals. This is essential in applications such as recording electrocardiograms (ECGs), weak vibration measurements, audio frequency measurements using microphones, and many other applications that employ sensors to collect input data. The interference can be occasionally reduced by proper grounding and using shielded cables, but can not be completely eliminated. An adaptive interference canceler with a reference input taken from the power-line (with proper attenuation) and the primary input taken from the sensor as shown in Fig. 2.18 can be used to achieve much better results. The adaptive interference canceler will also track any changes in the amplitude and phase of the power-line. In this application, only two filter coefficients are needed to track the phase and amplitude of the reference interference. Fig. 2.19 shows the input and output signals of the adaptive interference canceler shown in Fig. 2.18. The result shown in Fig. 2.19 can be regenerated by typing `powerline` in Matlab after installing ASPT. Using ASPT, it is easy to simulate the power-line interference canceler, as shown in the code below. In this code, the LMS algorithm is used to adjust a two-coefficient adaptive linear combiner. The two inputs to the line combiner are the interference $x1$ and a 90° phase shifted version of the interference, $x2$. The cleaned signal is the error of the adaptive line combiner. The same technique has also been used in many other applications such as canceling donor-heart interference in heart transplant ECG, and canceling the maternal ECG in fetal ECG, canceling noise in speech signals, and canceling antenna sidelobe interference [11].

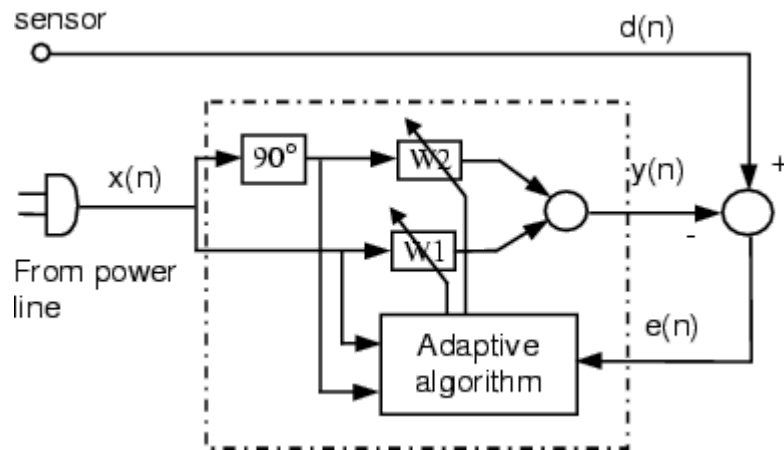


Figure 2.18: Block diagram of the power-line adaptive interference canceler.

```
% File = powerline.m
% This script simulates a power-line interference canceler.
iter = 1000;
Fs = 200; % sampling frequency
t = (1:iter) ./ Fs; % sampled time
f = 50 + (2*triang(iter)-1); % interference freq, 50 +/- 1 Hz
x1 = 0.2 * cos(2*pi*f.*t'); % interference
x2 = 0.2 * cos(2*pi*f.*t'-pi/2); % 90 deg phase shifted

% Load corrupted signal
load(strcat(asptdir,'data\powerline.mat'));
sc = s;
[w,x,d,y,e] = init_lms(2);
for n=1:iter
    [w,y,e] = asptlms([x1(n) ; x2(n)],w, s(n), 0.2);
    sc(n) = e;
end
```

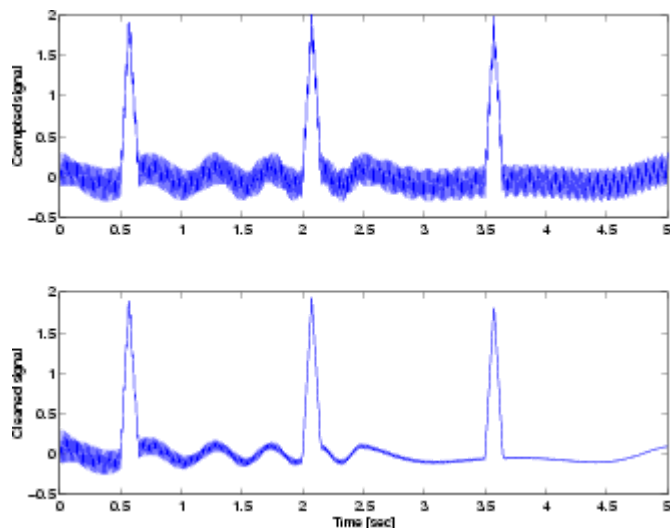


Figure 2.19: Input and output signals of an adaptive interference canceler.

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