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2 Linear Combiner Filters

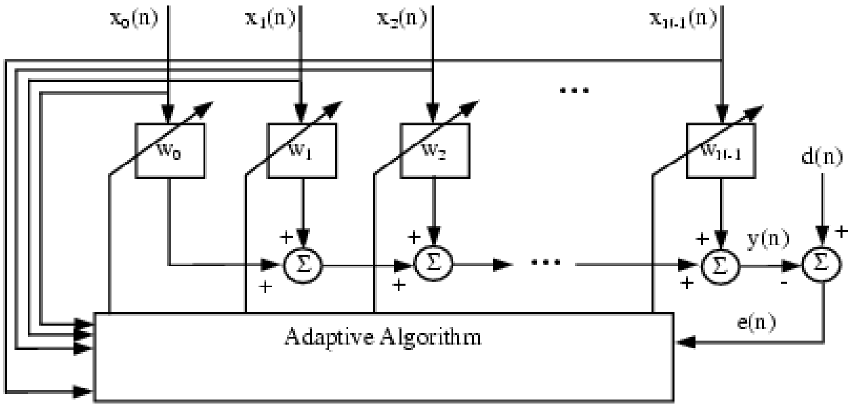

Figure 2.2: Linear combiner filter structure.

Linear combiner adaptive filters are very similar to transversal adaptive filters. The main difference is that the linear combiner input sequence is not necessarily temporal delayed samples of one single input, and it is therefore a generalized form of the transversal structure. The adaptive linear combiner filter structure is shown in Fig. 2.2. The input vector in the case of the linear combiner consists of temporal samples of several signals, that might be coming from an array of sensors for instance, and is expressed as $\underline{\mathbf{x}}(n) = [x_0(n)\ x_1(n)\ \cdots\ x_{N-1}(n)]^T$. Similar to the adaptive transversal filter, the adaptive linear combiner can be split into two main parts, the filter part and the update part. The function of the former is to calculate the filter output $y(n)$, while the function of the latter is to adjust the set of N filter coefficients $w_i, i = 0, 1, \cdots, N-1$ (tap weights) so that the output $y(n)$ becomes as close as possible to a desired signal $d(n)$. The filter part processes the set of input signals at each time index n to produces a single output sample $y(n)$ (assuming sample per sample implementation). The filter output at time index n is calculated as a linear combination of the input signals sampled at that time instance as,

$$y(n) = \sum_{i=0}^{N-1} w_i(n) \cdot x_i(n).$$

Expressing the set of N filter coefficients at time index n in vector notations such that $\underline{\mathbf{w}}(n) = [w_0(n)\ w_1(n)\ \cdots\ w_{N-1}(n)]^T$, where $(\cdot)^T$ is the vector transpose operator, eq (2.3) can be written as

$$y(n) = \underline{\mathbf{w}}(n)^T \cdot \underline{\mathbf{x}}(n) = \underline{\mathbf{x}}(n)^T \cdot \underline{\mathbf{w}}(n).$$

When the input signals are samples of sensor signals with the sensors placed at different positions in space, the linear combiner is a linear spatial filter that processes its input signals to produce the spatially filtered output $y(n)$. The filter coefficients are usually chosen such that the signals arriving from certain directions are passed to the output while signals arriving from other directions are rejected. Such filter is usually referred to as a beam former or an array processor. Similar to their transversal counterparts, adaptive linear combiner filters employ an adaptive algorithm to continuously adjust the filter coefficients so that a certain performance criterion is optimized in some sense. Regardless of the optimization method, it is usually desired to adjust the filter coefficients such that the filter output $y(n)$ resembles a desired signal $d(n)$ usually arriving from the "look direction", or equivalently, the error signal $e(n)$ must be minimized. The details of the optimization process defines the adaptive algorithm and its behavior. Although the adaptive signal processing toolbox contains adaptive algorithms that are widely used with linear combiner structures, such as the Linearly Constrained Least Mean Squares (see Section 4.8), any of the adaptive algorithms mentioned in

Section 2.2.1 can be used to update the linear combiner coefficients. The only necessary modification needed is to feed the adaptive algorithm with an input vector derived from temporal samples of N different signals rather than from delayed samples of a single signal.

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