



SNS COLLEGE OF TECHNOLOGY

An Autonomous Institution

Coimbatore-35



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Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

19ECB212 – DIGITAL SIGNAL PROCESSING

II YEAR/ IV SEMESTER

UNIT 5 – DSP APPLICATIONS

TOPIC – Adaptive Filters



ADAPTIVE FILTERS



- The term *Filter* is often used to describe a device in the form of a piece of physical hardware or software that is applied to a set of noisy data in order to extract information about a prescribed quantity of interest.
- An **adaptive filter** is a system with a linear filter that has a transfer function controlled by variable parameters and a means to adjust those parameters according to an optimization algorithm.
- An adaptive filter is one which can automatically design itself and can detect system variation in time.



DEFINING AN ADAPTIVE FILTER

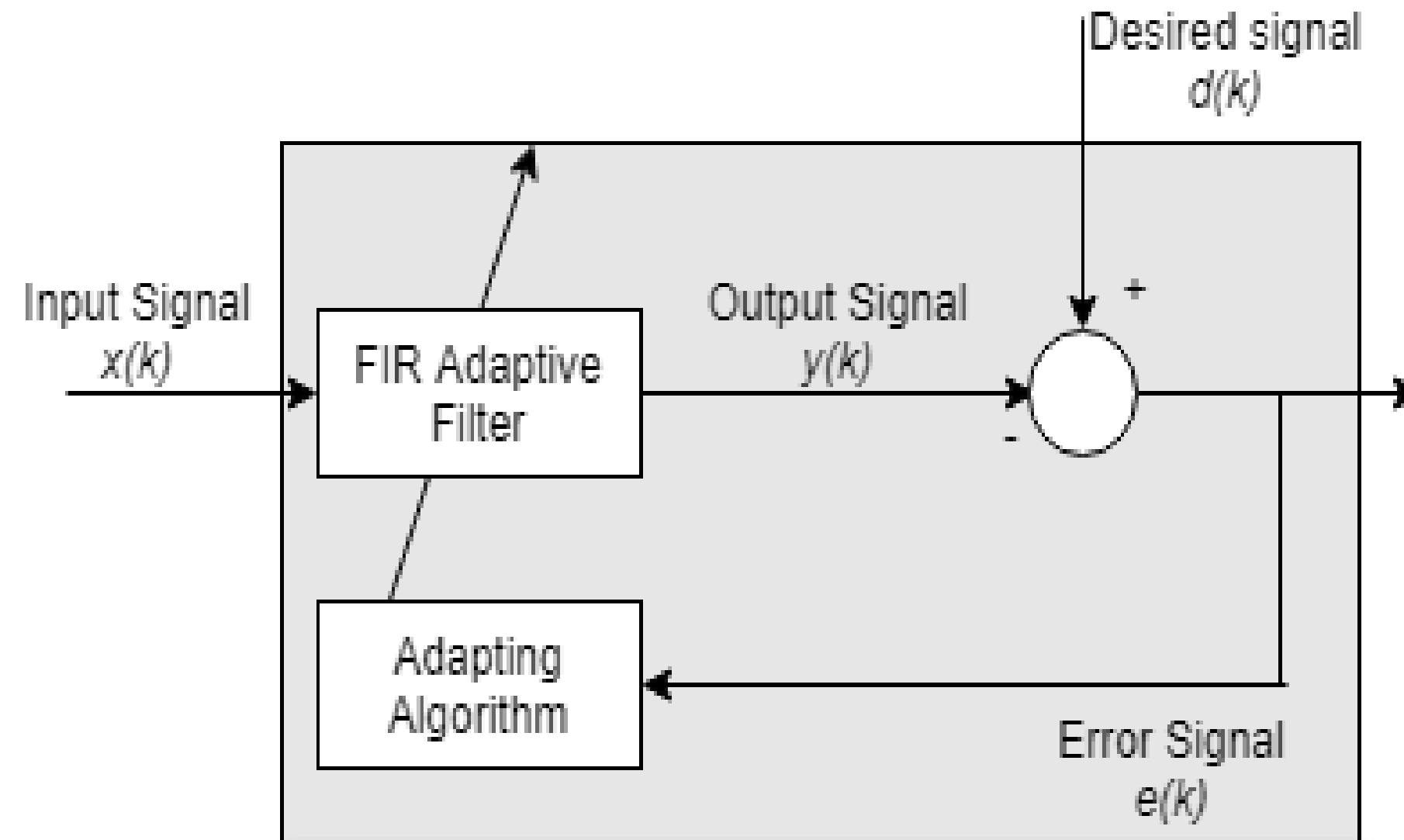


An adaptive filter is defined by four aspects:

1. The *signals* being processed by the filter.
2. The *structure* that defines how much the output signal of the filter is computed from its input signal.
3. The *parameters* within this structure that can be iteratively changed to alter the filter's input-output relationship.
4. The *adaptive algorithm* that describes how the parameters are adjusted from one time instant to next.



BLOCK DIAGRAM





BLOCK DIAGRAM EXPLANATION



- An adaptive filter consists of two distinct parts- a digital filter to perform the desired filtering, and an adaptive algorithm to adjust the coefficients of the filter.
- In the block diagram, where $d(k)$ is a desired (or primary input) signal, $y(k)$ is the output of a digital filter driven by a reference input signal $x(k)$, and an error signal $e(k)$ is the difference between $d(k)$ and $y(k)$.
- The adaptive algorithm adjusts the filter coefficients to minimize the mean-square value of $e(k)$.



BLOCK DIAGRAM EXPLANATION



- The optimization criterion is a cost function, which is most commonly the mean square of the error signal between the output of the adaptive filter and the desired signal.
- As the filter adapts its coefficients, the mean square error (MSE) converges to its minimal value.
- At this state, the filter is adapted and the coefficients have converged to a solution.
- The filter output, $y(k)$, is then said to match very closely to the desired signal, $d(k)$.
- When you change the input data characteristics, sometimes called *filter environment*, the filter adapts to the new environment by generating a new set of coefficients for the new data.



TYPES OF ADAPTIVE FILTERS



The Most common **types of Adaptive Filters** are,

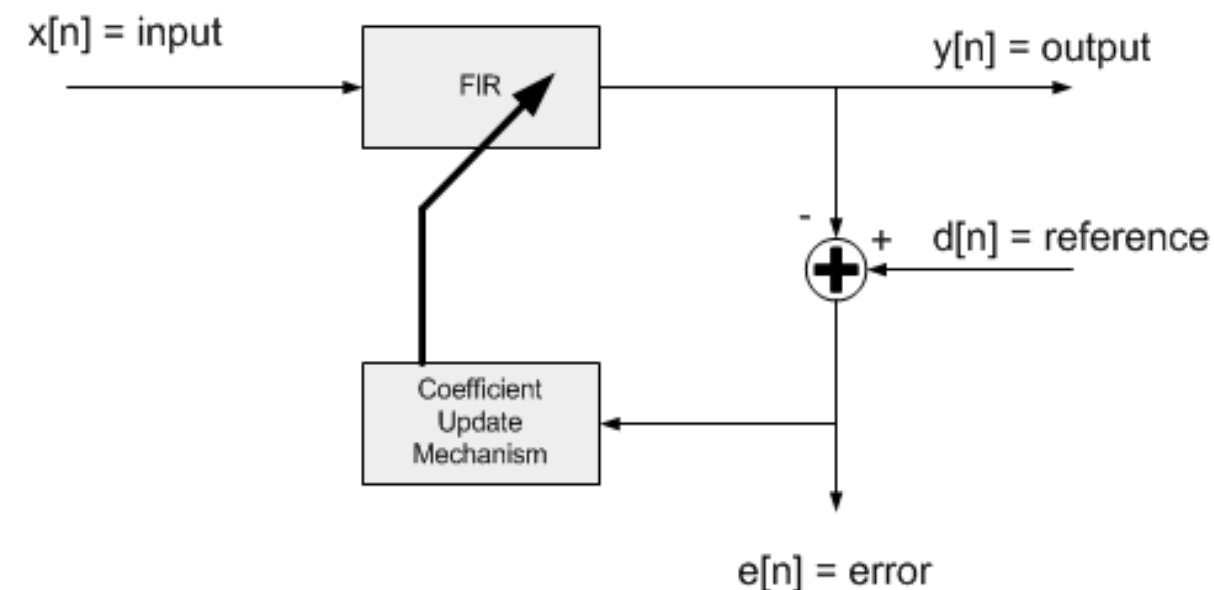
- **Least Mean Squares Filter (LMS)**
- **Recursive Least Squares Filter (RLS).**



LEAST MEAN SQUARES FILTER



- **Least mean squares (LMS)** algorithms are a class of adaptive **filter** used to mimic a desired **filter** by finding the **filter** coefficients that relate to producing the least mean square of the error signal (difference between the desired and the actual signal).





LEAST-MEAN-SQUARE (LMS) ALGORITHM



The LMS Algorithm consists of two basic processes,

1. Filtering process

- i) Calculate the output of FIR filter by convolving input and taps.
- ii) Calculate estimation error by comparing the output to desired signal.

2. Adaptation process

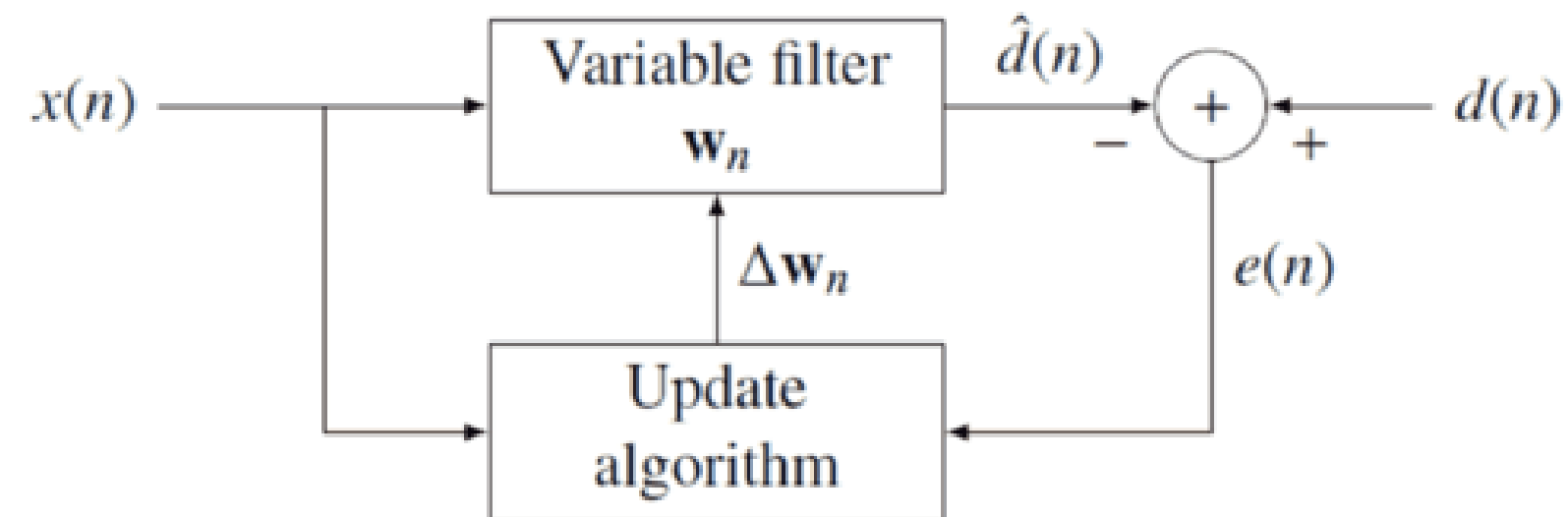
- i) Adjust tap weights based on the estimation error.



RECURSIVE LEAST SQUARES FILTER (RLS)



- **Recursive least squares (RLS)** is an adaptive **filter algorithm** that **recursively** finds the coefficients that minimize a weighted linear **least squares** cost function relating to the input signals.





THANK YOU