521324S SSP II — Matlab Simulation Exercise Task 4

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LMS Algorithm for Channel Equalizations(7 pts)

Deadline: February 14, 2024
(max 15 pages)

The purpose of the task is to implement the adaptive LMS algorithm for a channel equalization problem. You have been given a Matlab script where QPSK signals are transmitted over a 5-tap finite impulse response (FIR) delay line channel illustrated in Figure 1. The channel impulse response is assumed to be time-invariant. The received signals are distorted by the FIR channel and the additive noise term $v(n)$, as seen in Figure 1. The constellations of the input and output signals of the channel are illustrated in Figure 2(a) and 2(b), respectively.

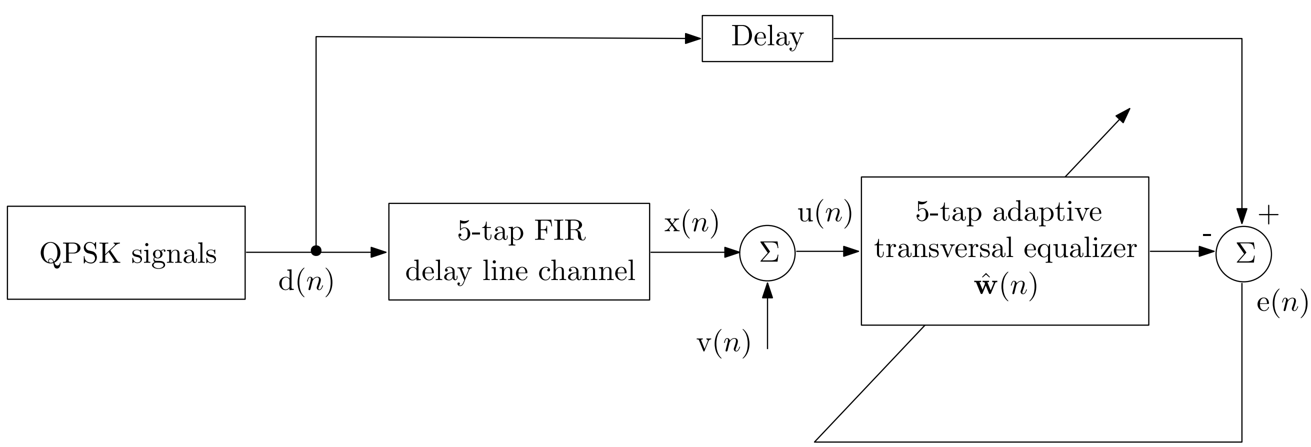

Fig. 1: Block diagram of an adaptive channel equalization.

The signal is equalized with an L-tap linear FIR equalizer with a smoother structure, the output constellation of which can be seen in Figure 2(c). The LMS algorithm is used for the equalizer control.

Task:

1) You are given an incomplete Matlab script. Therein, T denotes the number of training samples (i.e., known desired responses), and N is the length of data for the actual transmission. Let the length of the equalizer be $L = 20$. The step size of the LMS algorithm is set to $\mu = 0.01$. Let

   a) Write a Matlab code for an adaptive filter controlled by the LMS algorithm to equalize the signal distortion caused by the channel. If you do things correctly with the given parameters, you can draw a figure like the one in Figure 2(c).

   b) Change the simulation parameters, e.g., μ, and T and repeat Task 1(a). Observe the results and comment the impact of the parameters on the LMS algorithm performance.

c) Repeat Tasks 1(a) and 1(b) with $L = 10$ and $L = 30$ and give your comments.

Hint:

- In the Matlab script, we initialize the vector $\hat{\mathbf{w}}$ with zeros. Then, the three basic computations of the LMS algorithm are looped through the entire training period $1 : T$. Note that, for better equalization performance, the input desired response is delayed *EqD* time units before feeding to the adaptive equalizer, as illustrated in Figure 1 (see also *[Chapter 9.7, Haykin, 3rd Ed.]*. The training process outputs the weight vector which will be used to implement the equalizer.
- To evaluate the performance of the LMS algorithm, we estimate the bit-error-rate (BER) of the communications system using the equalizer with coefficient vector $\hat{\mathbf{w}}$. In particular, N data symbols are transmitted through the channels. The received signals are passed through equalizer $\hat{\mathbf{w}}$ before being demodulated. Then, the SER is estimated accordingly.

2) Write a Matlab code for the normalized LMS (NLMS) algorithm and repeat the simulations as in Task 1.

Note: In the report, you should demonstrate the advantages and disadvantages of the LMS and NLMS. The textbook has more details about those. Compare your results to the theory therein.

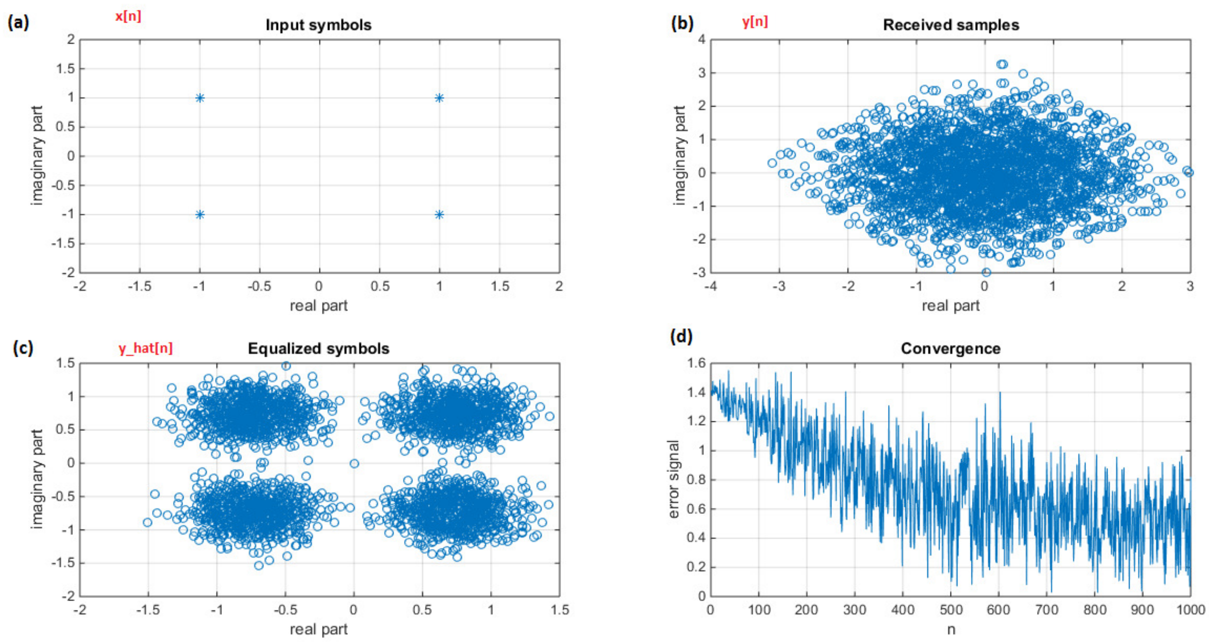

Fig. 2: Illustration of the signals: (a) constellation diagram of the input, (b) received constellation points, (c) constellation points at the equalizer output, (d) error signal convergence.