Universidade Federal do Ceará

Disciplina:	Filtros Adaptativos		
Professor(a):	Charles Casimirio		
Estudante:	Rubem Vasceconcelos Pacelli	Matrícula:	519024

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Lista 04

1 Question 1

For a adaptive filter where the input signal is given by $x(n) = \cos(\frac{\pi n}{3})$ and the desired signal is $d(n) = x(n+1)$, it is used the RLS algorithm with a forgetting factor of $\lambda = 0.98$. The signal output, $y(n)$, is shown in Figure 1 in addition to the input signal, $x(n)$.

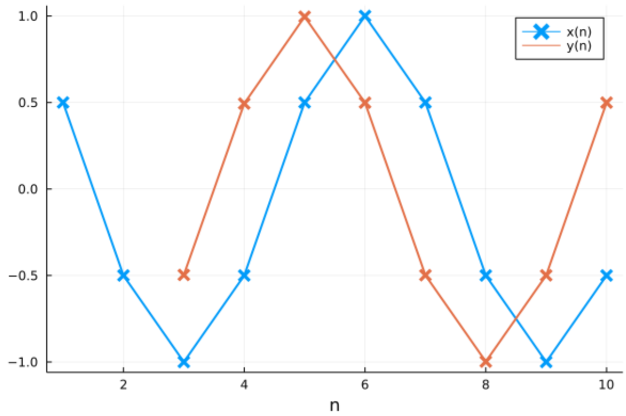


Figure 1: Value of $x(n)$ and its predicted value.

2 Question 2

Let $s(n)$ be a white Gaussian noise that passes through a channel whose transfer function is given by

$$H(z) = 1 + 1.6z^{-1}. \tag{1}$$

The signal output, $x(n) = s(n) + 1.6s(n-1)$, passes through an equalizer that uses the RLS algorithm with a forgetting factor of 0.99 to retrieve the transmitted signal. The Figure 2 shows the learning step of the coefficient vector, $\mathbf{w}(n)$, throughout the iterations. The Wiener solution is also plotted as a reference.

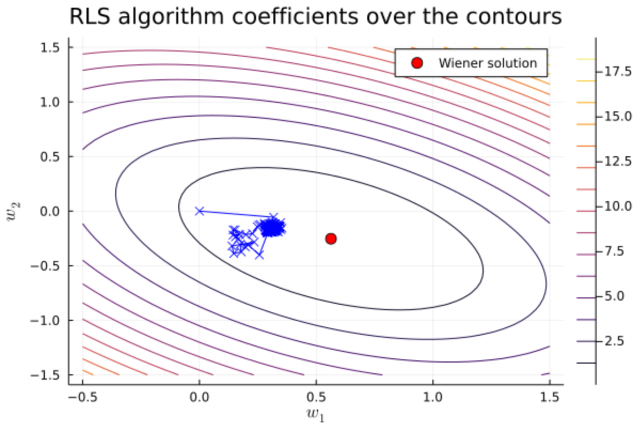


Figure 2: predicted coefficients.

The filter output and the desired sinal is shown in the Figure 3, and the MSE (mean squared error) of this algorithm is shown in Figure 4

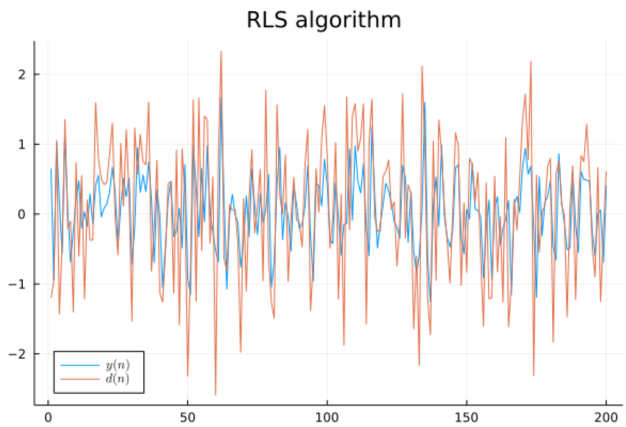


Figure 3: Filter output.

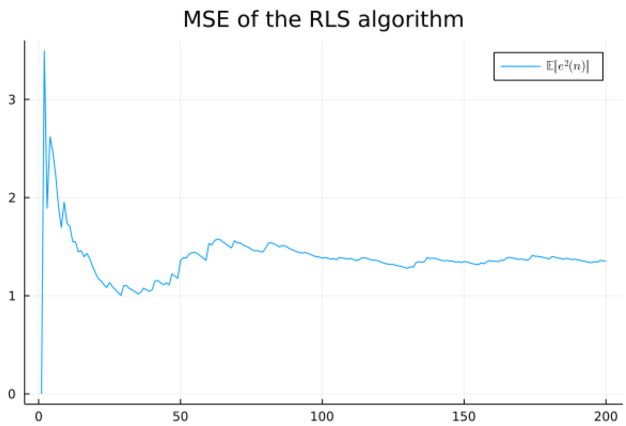
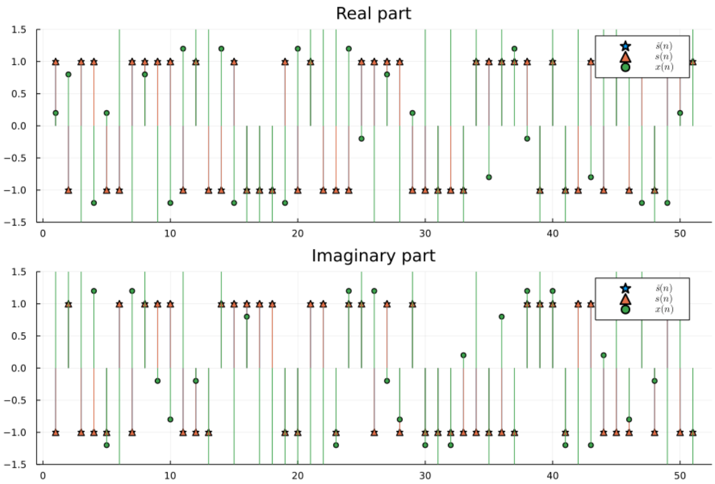


Figure 4: Filter output.

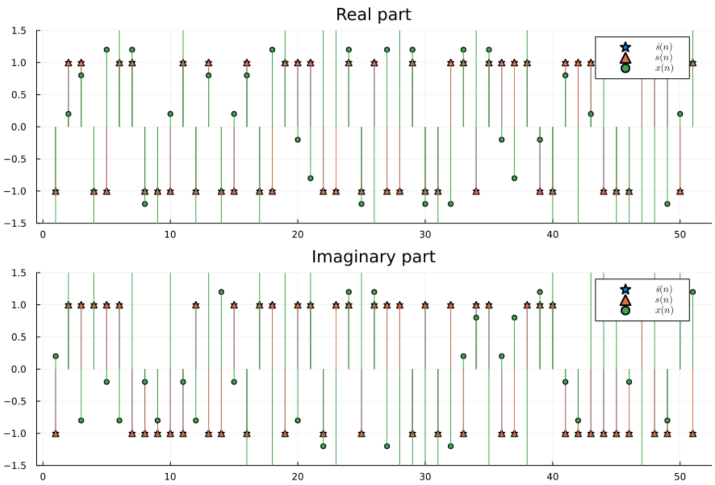
3 Question 5

The RLS algorithm with a forgetting factor of 0.9, 0.99, and 0.999 was computed for the same adaptive equalization problem of the homework 03. The model was trained with 500 symbols of a 4-QAM (Quadrature Amplitude Modulation) constellation. Then, the receiver operates in decision-directed mode for a 16-QAM scheme, under a SNR (Signal-to-Noise Ratio) of 30 dB. The result is obtained for $\lambda \in \{0.9, 0.99, 0.999\}$. The signal input, $x(n)$, the transmitted symbol, $s(n)$, and its estimate, $\hat{s}(n)$ are shown in Figure 5.

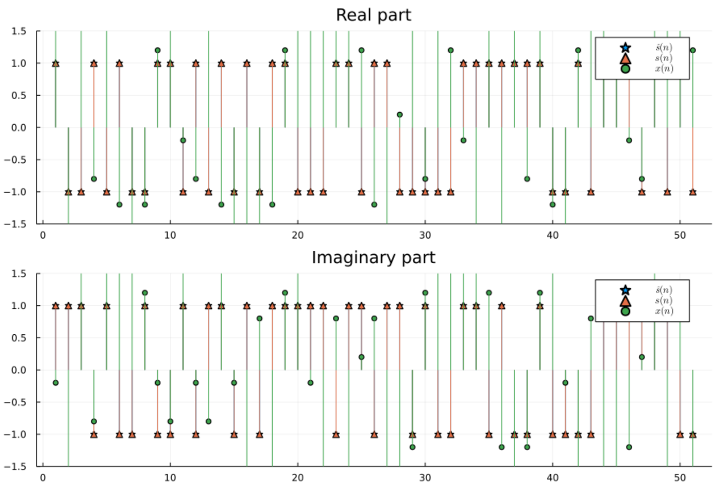
It is possible to see that the receiver can retrieve the transmitted symbol for all values of λ. Their convergences, however, vary with the value of λ, as shown in Figure 6.



(a) $\lambda = 0.9$



(b) $\lambda = 0.99$



(c) $\lambda = 0.999$

Figure 5: main caption

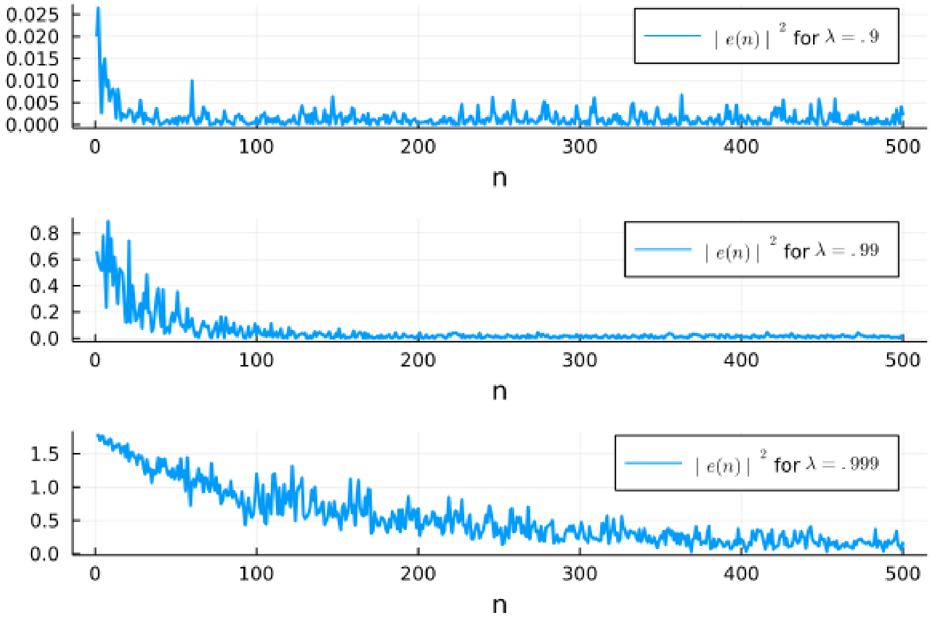


Figure 6: The absolute value of the error signal, $e(n) = d(n) - y(n)$, for different values of λ.