

Homework 8

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1. Noise corrupted

$$d(n) + w(n) = 1.2, 1.6, 1.8, 0.9, -0.4 \quad n = 1, 2, 3$$

$$\text{Ref } x(n) = 0.5, 0.6, 0.8, 0.6, 1.2, 0.4, 0.5 \quad n = -1, 0, 1, \dots$$

$$h_0(0) = \frac{1}{3} \quad h_0(1) = \frac{1}{3} \quad h_0(2) = \frac{1}{3} \quad \Delta = 0.2$$

$$y(1) = h_0(0)x(1) + h_0(1)x(0) + h_0(2)x(-1) = \frac{1}{3}(0.8 + 0.6 + 0.5) = 0.63$$

$$e(1) = d(1) - y(1) = [d(1) + w(1)] - y(1) = 1.2 - 0.633 = 0.567 = e(1)$$

$$h_1(0) = h_0(0) + \Delta e(1)x(1) = \frac{1}{3} + (0.2)(0.567)(0.8) = 0.424 = h_1(0)$$

$$h_1(1) = \frac{11}{3} + (0.2)(0.567)(0.6) = 0.4013 = h_1(1)$$

$$h_1(2) = \frac{1}{3} + (0.2)(0.567)(0.5) = 0.39 = h_1(2)$$

$$y(2) = h_1(0)x(2) + h_1(1)x(1) + h_1(2)x(0) = (0.424)(0.6) + (0.4013)(0.8) + (0.39)(0.6) = 0.80944$$

$$e(2) = d(2) - y(2) = [d(2) + w(2)] - y(2) = 1.6 - 0.809 = 0.7906 = e(2)$$

$$h_2(0) = 0.424 + (0.2)(0.7906)(0.6) = 0.5189 = h_2(0)$$

$$h_2(1) = 0.4013 + (0.2)(0.7906)(0.8) = 0.5278 = h_2(1)$$

$$h_2(2) = 0.39 + (0.2)(0.7906)(0.6) = 0.4849 = h_2(2)$$

$$y(3) = h_2(0)x(3) + h_2(1)x(2) + h_2(2)x(1) = (0.519)(1.2) + (0.5278)(0.6) + (0.4849)(0.8) = 1.327$$

$$e(3) = [d(3) + w(3)] - y(3) = 0.47272 = e(3)$$

$$\bullet h_3(0) = (0.5189) + (0.2)(0.473)(1.2) = \boxed{0.6324 = h_3(0)}$$

$$\bullet h_3(1) = 0.5278 + (0.2)(0.473)(1.6) = \boxed{0.5846 = h_3(1)}$$

$$\bullet h_3(2) = (0.4449) + (0.2)(0.473)(0.8) = \boxed{0.5606 = h_3(2)}$$

$$a) \bullet h_1(0.2) = [0.424 \quad 0.4013 \quad 0.390]$$

$$\bullet h_2(0.2) = [0.5819, 0.5278, 0.7899]$$

$$\bullet h_3(0.2) = [0.632, 0.5846, 0.5606]$$

$$b) \left\{ \begin{array}{l} e(1) = 0.5667 \\ e(2) = 0.7904 \\ e(3) = 0.4727 \end{array} \right\}$$

CODE AND PLOTS**%% Question 2**

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clear all; close all; clc
n = 50;
x = rand(n,1)*4 - 2;
P = mean(x.^2);
Ns = [8 16 32];
deltas = 1./(10.*Ns.*P);

%% Create Black Box Filter
% Black Box
b = [1 4 -1];
a = [1 -0.3 0.1];
d = filter(b,a,x);

% Plots
% figure
% freqz(b,a)
% title('Filter Response')
figure
n_plts = 2+2*length(deltas);
subplot(n_plts,1,1); plot(x);
title('Random Input Data (x)'); grid;
xlabel('n'); ylabel('Amplitude');
subplot(n_plts,1,2); plot(d);
title('Unknown Filtered Data (d)'); grid;
xlabel('n'); ylabel('Amplitude');

%% Try each N for Adaptive Filter
for i = 1:length(Ns)
    N = Ns(i);
    del = deltas(i);

    %LMS Adaptive Filter
    h=zeros(N,1); %initial values: 0
    M=length(x); %number of samples of the input signal
    e = zeros(N,1);
    for n=N:M
        xvec=x(n:-1:n-N+1);
        e(n) = d(n) - h' * xvec;
        h=h + del * xvec * conj(e(n));
    end
    d_aprx = filter(h,1,x);

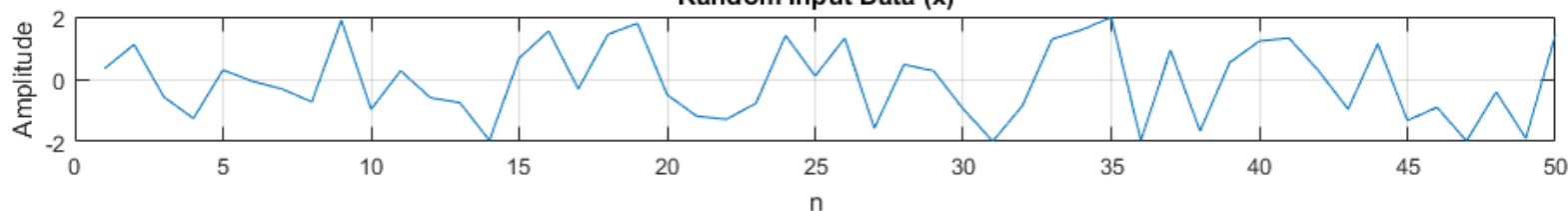
    % Error
    e = e(e~=0); % clean up 0s
    mse = immse(d,d_aprx);

%% Plots
subplot(n_plts,1,2+i*2-1); plot(d_aprx);
title(sprintf('Adaptive Filtered Data for N = %d, delta = %0.2d', N, del)); grid;
xlabel('n'); ylabel('Amplitude');

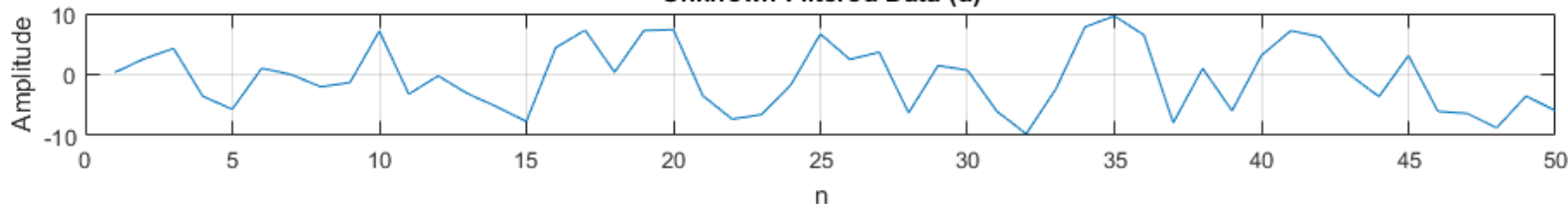
subplot(n_plts,1,2+i*2); plot(e.^2);
title(sprintf('Adaptive Filter Squared Error for N = %d, mse = %0.2d', N, mse)); grid;
xlabel('n'); ylabel('e^2');
end

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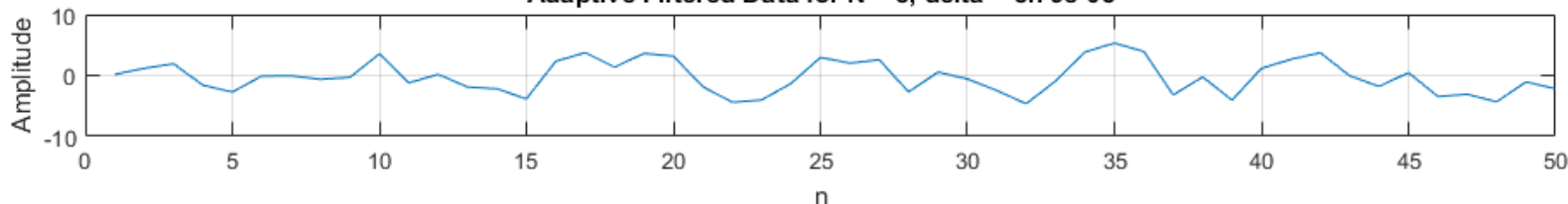
Random Input Data (x)



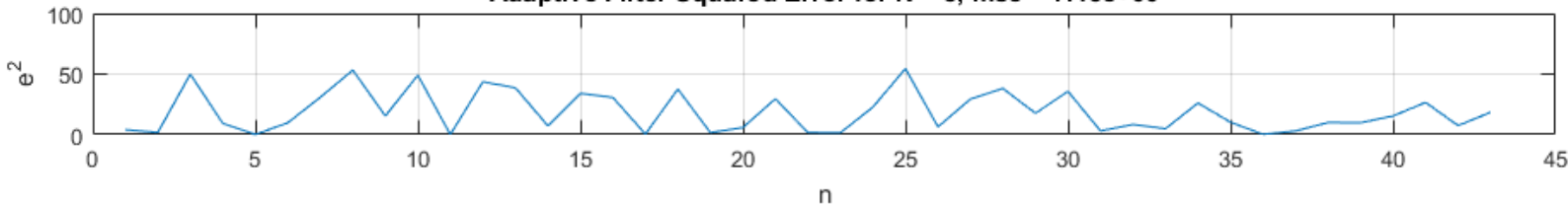
Unknown Filtered Data (d)



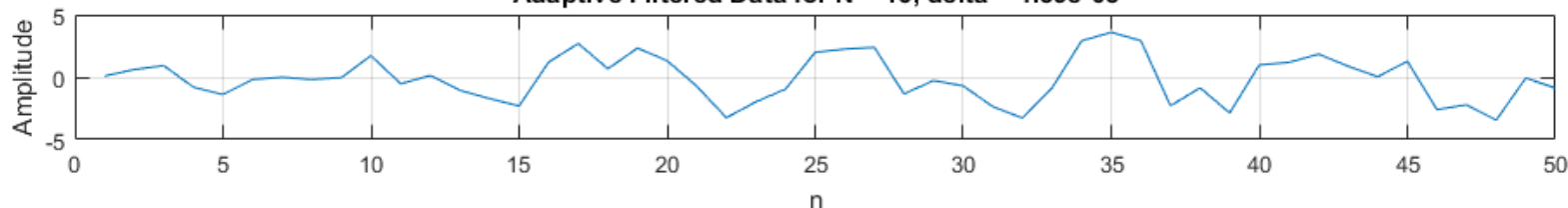
Adaptive Filtered Data for N = 8, $\delta = 8.79e-03$



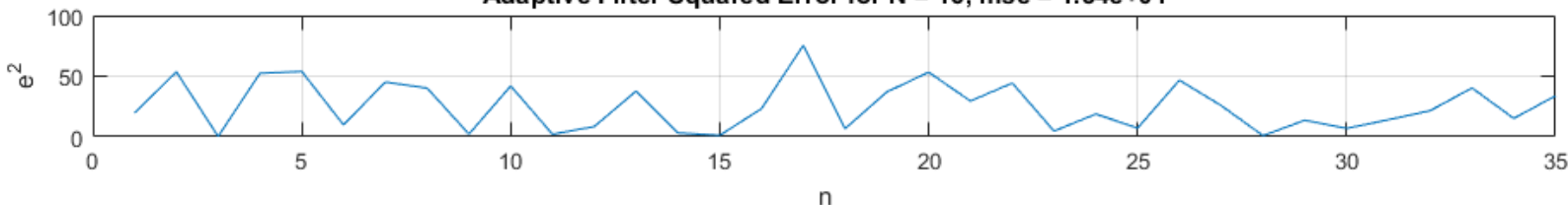
Adaptive Filter Squared Error for N = 8, $mse = 7.43e+00$



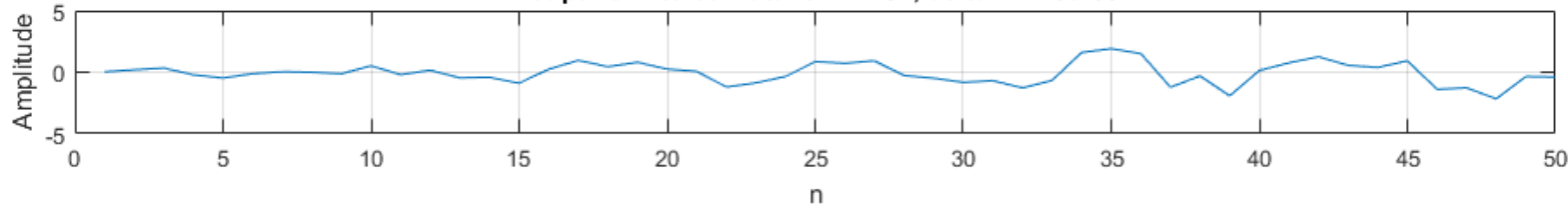
Adaptive Filtered Data for N = 16, $\delta = 4.39e-03$



Adaptive Filter Squared Error for N = 16, $mse = 1.34e+01$



Adaptive Filtered Data for N = 32, $\delta = 2.20e-03$



Adaptive Filter Squared Error for N = 32, $mse = 2.07e+01$

