Homework 8

Jake Garrison

1. Noise corrupted

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

Ref $x(n) = 0.5\ 0.6\ 0.8\ 0.6\ 1.2\ 0.4\ 0.5 \quad n = -1, 0, 1 \ldots$

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

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

0.63

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

$= 1.2 - 0.633 = \boxed{0.567 = e(1)}$

- $h_1(0) = h_0(0) + \Delta e(1)x(1) = \frac{1}{3} + (0.2)(0.567)(0.8) = \boxed{0.424 = h_1(0)}$
- $h_1(1) = \frac{1}{3} + (0.2)(0.567)(0.6) = \boxed{0.4013 = h_1(1)}$
- $h_1(2) = \frac{1}{3} + (0.2)(0.567)(0.5) = \boxed{0.39 \quad h_1(2)}$

$y(2) = h_1(0)x(1) + h_1(1)x(0) + h_1(2)x(-1)$

$= (0.424)(0.6) + (0.4013)(0.8) + (0.39)(0.6) = 0.80944$

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

$= 1.6 - 0.809 = \boxed{0.7906 = e(2)}$

- $h_2(0) = 0.424 + (0.2)(0.7906)(0.6) = \boxed{0.5189 = h_2(0)}$
- $h_2(1) = 0.4013 + (0.2)(0.7906)(0.2) = \boxed{0.5278 = h_2(1)}$
- $h_2(2) = 0.39 + (0.2)(0.7906)(0.6) = \boxed{0.4849 = h_2(2)}$

$y(3) = h_2(0)x(3) + h_2(1)x(2) + h_2(2)x(1)$

$= (0.519)(1.2) + (0.5278)(0.6) + (0.4849)(0.8) = 1.327$

$e(3) = [d(3) + w(3)] - y(3) = \boxed{0.47272 = e(3)}$

- $h_3(0) = (0.5189) + (0.2)(0.473)(1.2) = 0.6324 = h_3(0)$
- $h_3(1) = 0.5278 + (0.2)(0.473)(0.6) = 0.5846 = h_3(1)$
- $h_3(2) = (0.4749) + (0.2)(0.473)(0.8) = 0.5606 = h_3(2)$

a)
- $h_1(0:2) = [0.424 \quad 0.4013 \quad 0.390]$
- $h_2(0:2) = [0.5819, 0.5278, 0.4847]$
- $h_3(0:2) = [0.632; 0.5846 \quad 0.5606]$

b)
$$\begin{cases} e(1) = 0.5667 \\ e(2) = 0.7906 \\ e(3) = 0.4727 \end{cases}$$

CODE AND PLOTS

%% Question 2

```
clear all; close all; clc
n = 1000;
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); %inital 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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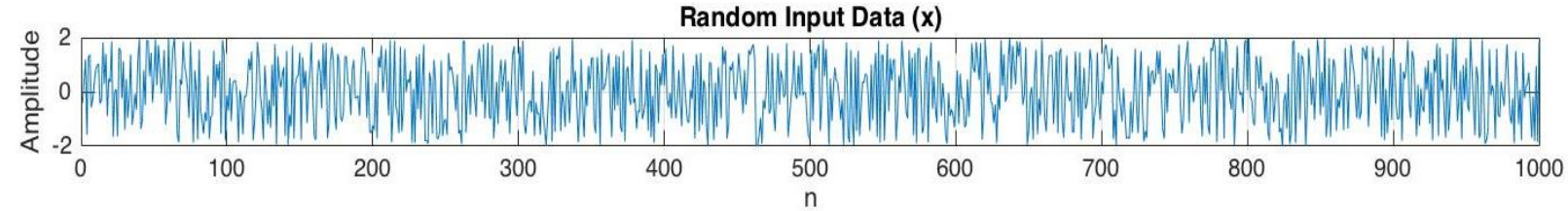
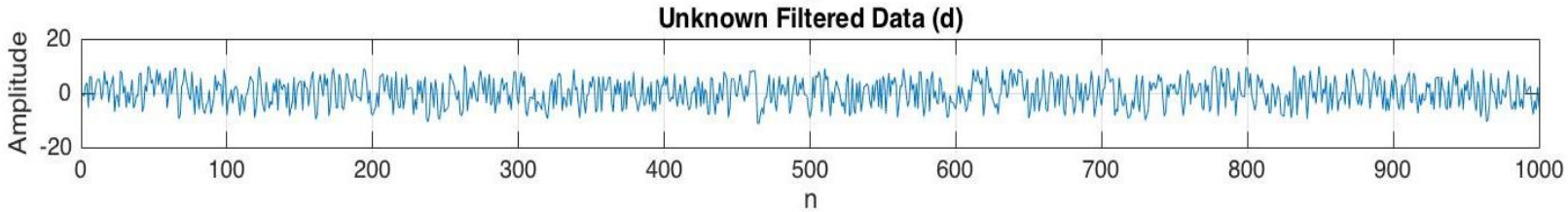
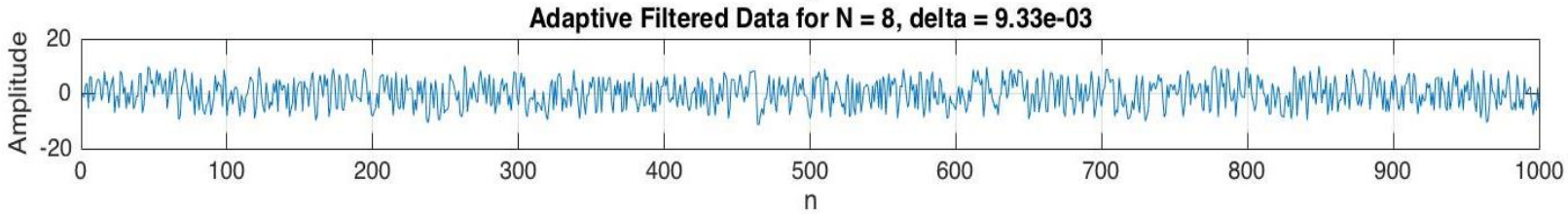
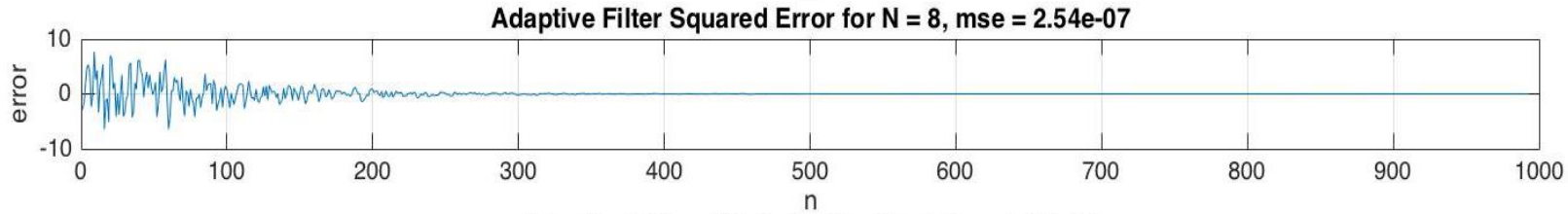
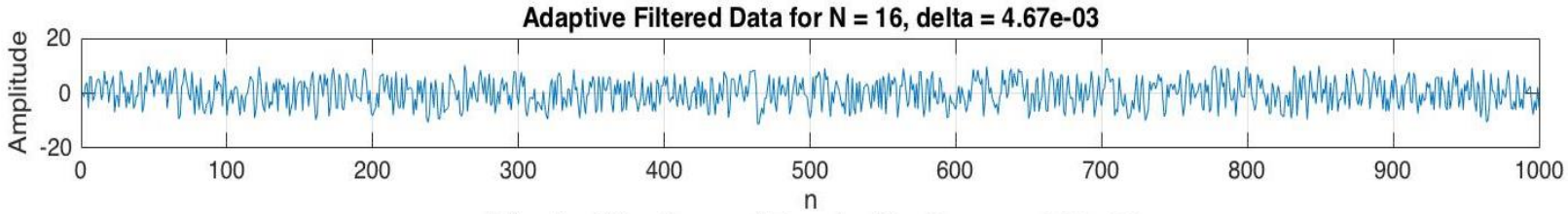
Time Domain Plots

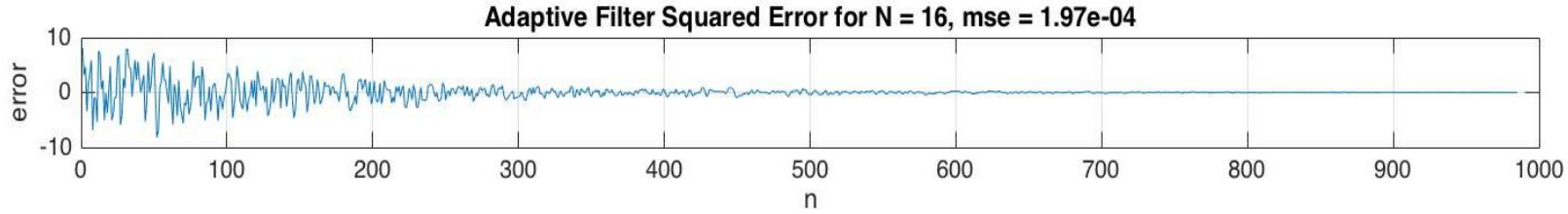


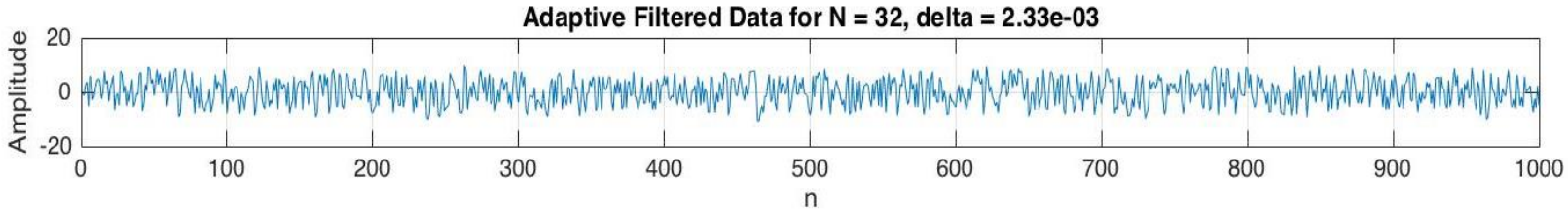


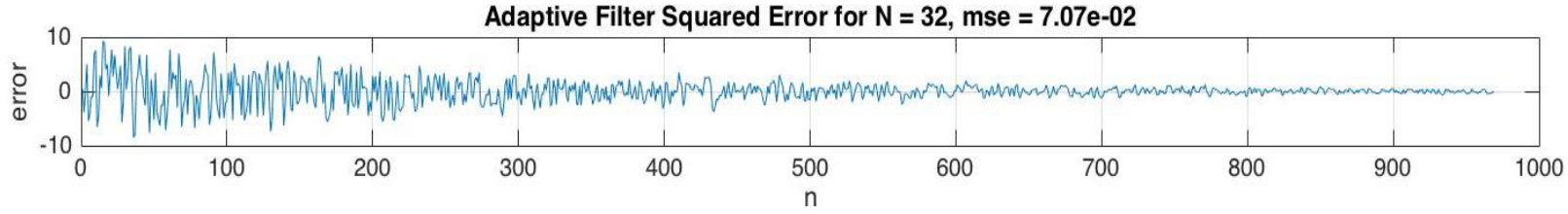












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Frequency Domain Plots