Experiment 4
Identification of Discrete Time System using Adaptive filtering

Objective: To use adaptive LMS filtering for system identification.
Procedure:

a) Step 1: Generation of input signal and noise signal

Generate the input signal u(n) which is zero mean unity variance sequence of length 1824.

In MATLAB, a white noise sequence with zero mean and unity variance of length *N* can be constructed as follows:

```
randn('state', 7) % choose a state for subsequent construction
u = randn(N,1); %N is the length
m = mean(u);
u = u –m; % to ensure a zero mean value
vr = var(u);
u = u/sqrt(vr); % to ensure an unity variance
```

Generate a noise signal v(n) which has a zero mean ,variance $\sigma_v^2 = 1e - 6$ and length 1800 as follows.

```
randn('state', 123) % choose a state for subsequent construction
v = randn(N,1); %N is the length
m = mean(v);
v = v –m;
vr = var(v);
v = sqrt(sig2/vr)*v; % where sig2 denote the variance of v(n)
```

b) Step II : Constructing an FIR unknown system and obtaining unknown system response and desired response from it

Construct an FIR unknown system of length M_1 = 21 and cut off frequency fc = 0.5 using hamming window.

```
h = fir1(M1–1, fc);
```

Plot the frequency response of the system as

```
[H,w] = freqz(h,1,1024);
plot(w/pi,20*log10(abs(H)))
axis([0 1 0 -100 10])
grid
title('Frequency response of the unknown system')
xlabel('Normalized frequency')
ylabel('Amplitude')
```

Generate the output sequence x(n) and desired response d(n) for each n value. (This part can be done within the next step)

c) Step III: System Identification

The method of adaptive system identification is as follows:

a) First define a zero vector w_sum for summing the weight vectors obtained over different iterations. Now define a zero vector e_sqr_sum to sum the square of errors over every iteration.

b) You can proceed with the loop as follows:

For i = 1: number of iterations

Do the Step 1 – Generation of input and noise for each iteration
(Note that state has to be different for different iterations. It is desirable to use randn('state', 7 + i) and randn('state', 123 + i) inside the loop for signal and noise respectively))

Define zero vectors for e and w.

For each n

define $\hat{u}$	$\hat{u} = \underbrace{\left[u(n+M-1) \;\; u(n+M-2) \;\; \cdots \;\; u(n+1) \;\; u(n)\right]}_{M}$
$x = h \cdot \hat{u}^T$	x(n) is the output value at time n of the unknown filter when we input M samples of the pilot signal
$d(n) = x(n) + v(n)$	d(n) is a scalar, namely the desired output (output of unknown filter, contaminated with noise)
$y(n) = w \cdot \hat{u}^T$	y(n) is a scalar, namely the response of the adaptive filter to M samples of the pilot signal
$e(n) = d(n) - y(n)$	e(n) is a scalar, namely the estimation error
$w = w + \mu \cdot e(n) \cdot \hat{u}$	update adaptive filter coefficients

End

Add w to w_sum
Add pointwise square of e to e_sqr_sum

End

c) Take the average w_avg and e_avg by dividing w_sum and e_sqr_sum by number of cases.

Step IV: Performance Evaluation

a) Plot the average squared error using the semilogy command. (for reference see figure L4.2 lab manual) Study the plot and draw conclusions regarding the convergence of the algorithm in terms of numbers of iterations and stability.
b) Compare the two systems by listing their impulse responses side by side in a table (use format long). (see pg. 4-5 lab manual)
c) Compute and include in your report the norm of the error between the two sets of coefficients
d) Plot the amplitude responses of the two systems in the same graph.

You have to perform system identification with M = 21 and step size μ = 0.01, one smaller value than μ = 0.01 and one larger value.
Repeat the whole thing with M = 25.

<u>Bonus Question:</u>

Section 4.3.5 (lab manual pg. 4-6 and 4-7)

- Include the following table in your lab report. (Use the values for the step size as in the table below)

Step size μ	**Convergence rate [ITERATIONS] (approximate)**		**Error**	
	M = 21	**M = 25**	**M = 21**	**M = 25**
0.01				
0.0075				
0.0125				

- Comment on the results obtained.