113EC0199 **SAGNIK BASU**

Channel Equalization using MLP

Matlab Code :

```
clc;
clear all;
close all;
c=input('Channel order');
experiments =50.0;



%noise=2*rand(1,samples)-1;  %%noise(bias)
%%channel 1
%y1=inp+noise;


samples=1000;
x=2*rand(1,samples)-1;
inp=zeros(1,samples);

inp=zeros(1,samples);
for i=1:length(x)    %%generation of inputs
    if(x(i)<0)
        inp(i)=-1;
    else if(x(i)>0)
            inp(i)=1;
        else
            inp(i)=0;
        end
    end
end



SNR=5;

%y1=awgn(inp,SNR);
y2=[inp(2:length(inp)) inp(1)];
y4=[inp(3:length(inp)) inp(1:2)];
y3=(0.364*inp)+(0.86*y2)+(0.364*y4);
r=awgn(y3,SNR);
```

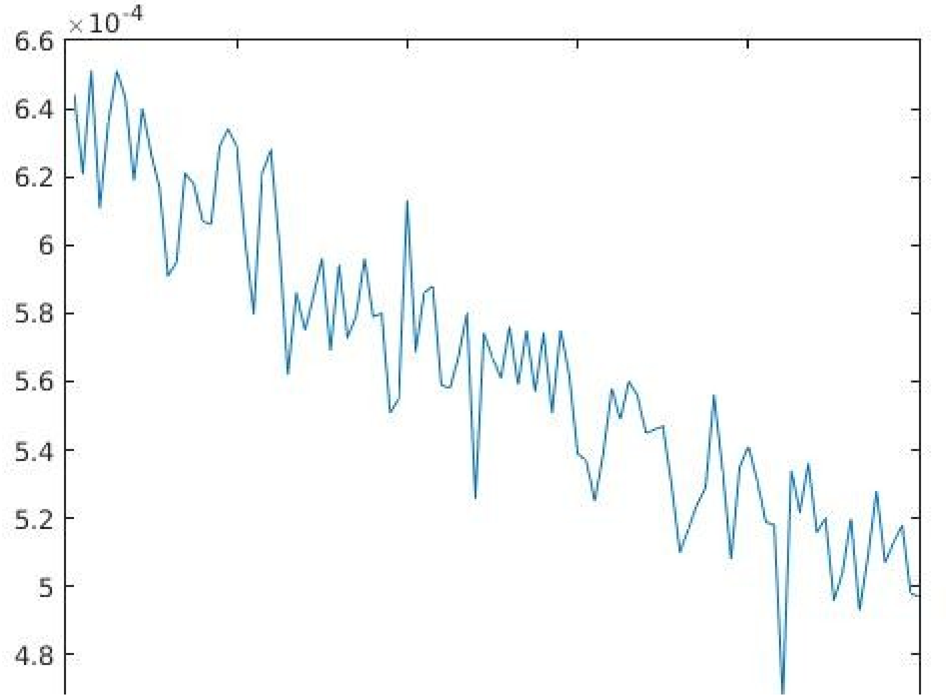
```
%weights=2*(rand(1,c))-1;
%bias=2*rand(1,1)-1;   %%bias for the perceptron

weights=-1+2.*rand(2,2*c);
weights_b= -1+2.*rand(1,2*c);
weightsb_out= -1+2.*rand(1,1);

bias = [-1 -1 -1 -1 ];
%iterations = constant;
coeff=0.5;



y=zeros(1,samples);
output=zeros(1,samples);
error=zeros(1,samples);
err_train=zeros(1,samples);
%%final_err_train=0;



for j=1:samples-c
                              %% input1(:,j)=input(:,r);
% y(1,j)=y1(1,j:j+c-1)*(transpose(weights))+bias;
                              %%out(1,j) = (1/(1+exp(-y(1,j))));
                              %%e=d_out(r)-out(j);
 %output(1,j)=hardlims(y(1,j));

 %MSE Calculation for 50 experiments
 final_err_mse2=0;



     H1 = bias(1,1)*weights_b(1,1)+r(1,j)*weights(1,1)+ r(1,j+1)*weights(1,2);

     % Send data through sigmoid function 1/1+e^-x
     % Note that sigma is a different m file
     % that I created to run this operation
     x2(1) = tanh(H1);

     H2 = bias(1,2)*weights_b(1,2) + r(1,j)*weights(1,3) + r(1,j+1)*weights(1,4);
     x2(2) = tanh(H2);

     %H3 = bias(1,3)*weights_b(1,3) + x(i)*weights(1,5) + y(i)*weights(1,6);
     %x2(3) = tanh(H3);

     %H4 = bias(1,4)*weights_b(1,4) + x(i)*weights(1,7) + y(i)*weights(1,8);
     %x2(4) = tanh(H4);



     %H2 = bias(1,4)*weights(1,4) + x(i)*weights(2,2) + y(i)*weights(2,3);
     %x2(3) = tanh(H2);



     % Output layer
     x3_1 = bias(1,4)*weightsb_out(1,1)+ x2(1)*weights(2,1)+x2(2)*weights(2,2);%
```

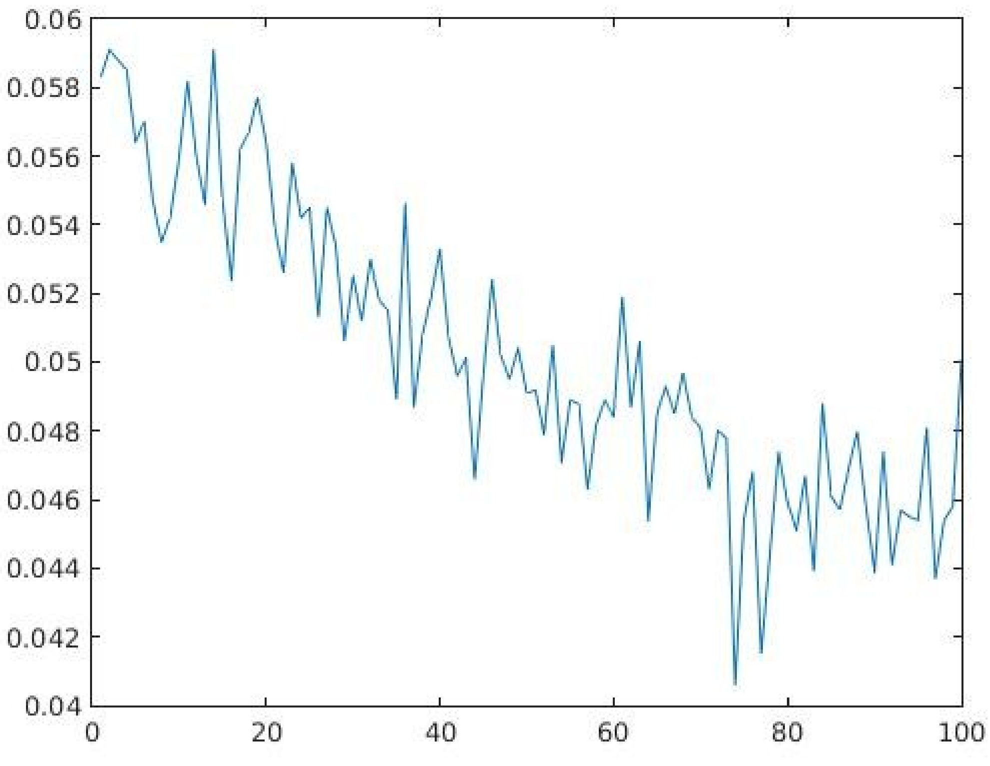
```
+x2(3)*weights(2,3);%+x2(4)*weights(2,4);
     out(j) =tanh(x3_1);









 for k=1:experiments
    y_mse2(1,k)=bias(1,4)*weightsb_out(1,1)+ x2(1)*weights(2,1)+x2(2)*weights(2,2);
    output_mse2(1,k)=tanh(y_mse2(1,k));
    error_mse2(1,k)=inp(1,k)-output_mse2(1,k);
    final_err_mse2=final_err_mse2+error_mse2(1,k)*error_mse2(1,k);
 end

 mse_2(j)=final_err_mse2/experiments;

     delta3_1 = (1-out(j)*out(j))*(inp(j)-out(j));
     %delata3_1=(output(i)-out(i));
     % Propagate the delta backwards into hidden layers
       %delta2_1 = x2(1)*(1-x2(1))*weights(3,2)*delta3_1;
       %delta2_2 = x2(2)*(1-x2(2))*weights(3,3)*delta3_1;


      delta2_1 = (1-x2(1)*x2(1))*weights(2,1)*delta3_1;
      delta2_2 = (1-x2(2)*x2(1))*weights(2,2)*delta3_1;
     % delta2_3 = (1-x2(2)*x2(2))*weights(2,3)*delta3_1;

       weights_b(1,1) = weights_b(1,1) + coeff*bias(1,1)*delta2_1;
       weights_b(1,2) = weights_b(1,2) + coeff*bias(1,2)*delta2_2;
       %weights_b(1,3) = weights_b(1,3) + coeff*bias(1,3)*delta2_3;
       %weightsb(1,4) = weightsb(1,4) + coeff*bias(1,4)*delta2_4;
       weightsb_out  = weightsb_out  +  coeff*bias(1,4)*delta3_1;


           weights(1,1) = weights(1,1) + coeff*r(1,j)*delta2_1;
           weights(1,2) = weights(1,2) + coeff*r(1,j+1)*delta2_1;
           weights(1,3) = weights(1,3) + coeff*r(1,j)*delta2_2;
           weights(1,4) = weights(1,4) + coeff*r(1,j+1)*delta2_2;


           weights(2,1) = weights(2,1) + coeff*x2(1)*delta3_1;
           weights(2,2) = weights(2,2) + coeff*x2(2)*delta3_1;


 %%training
 %error(1,j)=inp(1,j)-output(1,j);
 %%err_train(j)=error(1,j)*error(1,j);
 %bias=bias+error(1,j);
 %weights=weights+error(1,j)*y1(1,k:k+c-1);
 %weights_array(j,:)=weights;
 %%weights_final(j,:,k)= weights;
 %%bias_final(j,1,k) = bias;
 %%error(j,1,k) = e;

end

%%Testing
```

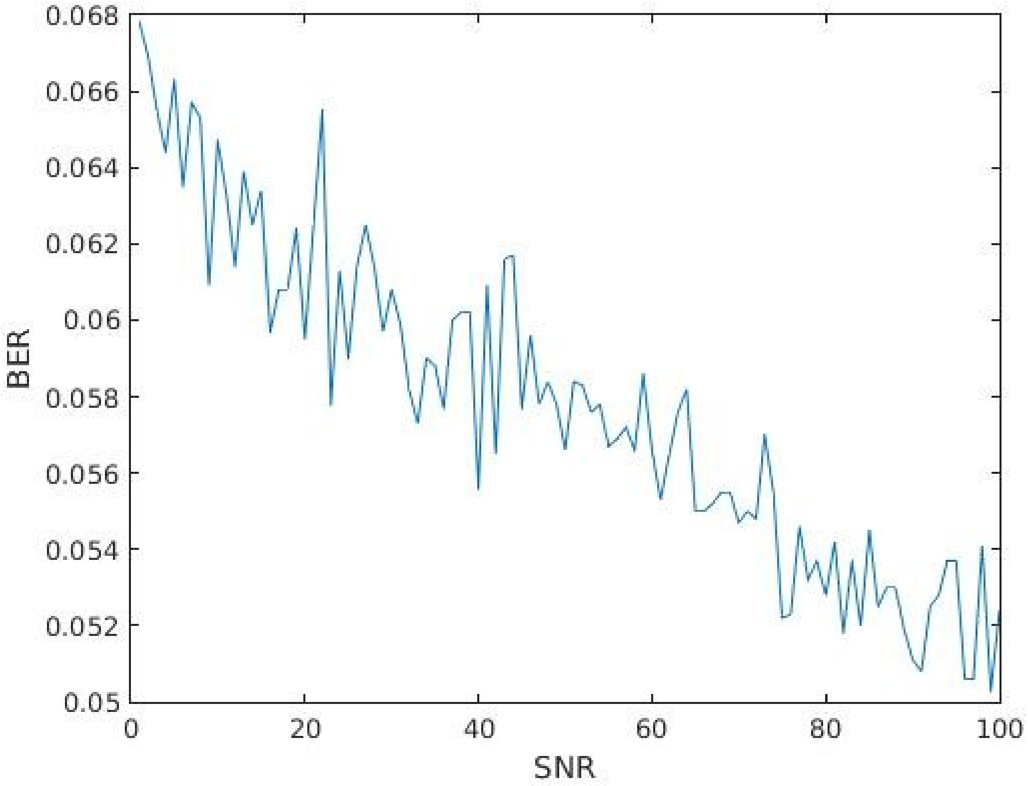
```
testing_size=1000;
y_test=2*rand(1,testing_size)-1;
input=zeros(1,50);
final_err=0;
mse=zeros(1,50);
SNR=1;
for k=1:100
    y_test=2*rand(1,testing_size)-1;
    input=zeros(1,testing_size);
for i=1:length(y_test)    %%generation of inputs
    if(y_test(i)<0)
        input(i)=-1;
    else if(y_test(i)>0)
            input(i)=1;
        else
            input(i)=0;
        end
    end
end
final_err=0;
SNR_arr(k)=SNR+k/10;
y1=awgn(input,SNR_arr(k));
BER=0;
for i=1:testing_size-c+1

   % y1_test(1,i)=y1(1,i:i+c-1)*(transpose(weights))+bias;
   % percp_out(1,i)=hardlims(y1_test(1,i));
   % error_test(i)=percp_out(1,i)-input(1,i);

    H1 = bias(1,1)*weights_b(1,1)+y(1,j)*weights(1,1)+ y(1,j+1)*weights(1,2);

      % Send data through sigmoid function 1/1+e^-x
      % Note that sigma is a different m file
      % that I created to run this operation
      x2(1) = tanh(H1);

      H2 = bias(1,2)*weights_b(1,2) + y(1,j)*weights(1,3) + y(1,j+1)*weights(1,4);
      x2(2) = tanh(H2);

      x3_1 = bias(1,4)*weightsb_out(1,1)+ x2(1)*weights(2,1)+x2(2)*weights(2,2);%
+x2(3)*weights(2,3);%+x2(4)*weights(2,4);
      out(i) = hardlims(tanh(x3_1));


   error_test(i)=out(1,i)-input(1,i);

   if(error_test(i)==0)
   else
        BER=BER+1;
 end
end
    %final_err=final_err+error_test(i)*error_test(i);
BER_arr(k)=BER/1000;

end
%mse(k)=final_err/1000.0;




%axis([-3 3 -3 3]);
%w1=-bias/weights(1,1);
```

```
%w2=-bias/weights(1,2);
%plot([w1,0],[0,w2]);
%hold on;



%plotpv(inp,inp);
%hold on;
%plotpc(weights,bias);
```

BER Curves for delay elements(-2/-3/-4)



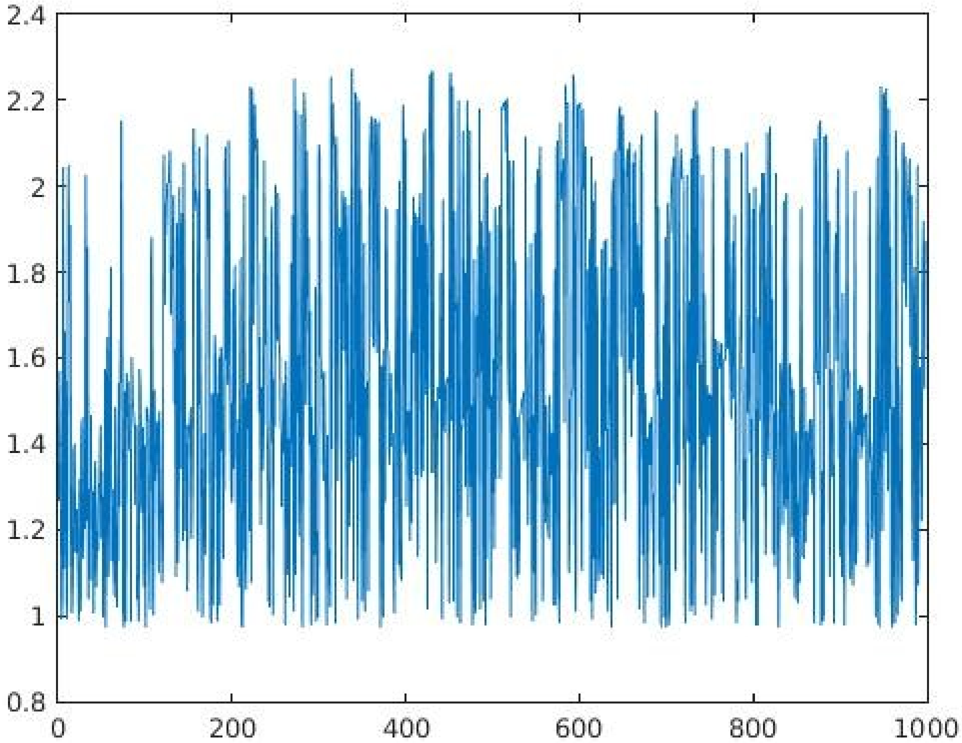




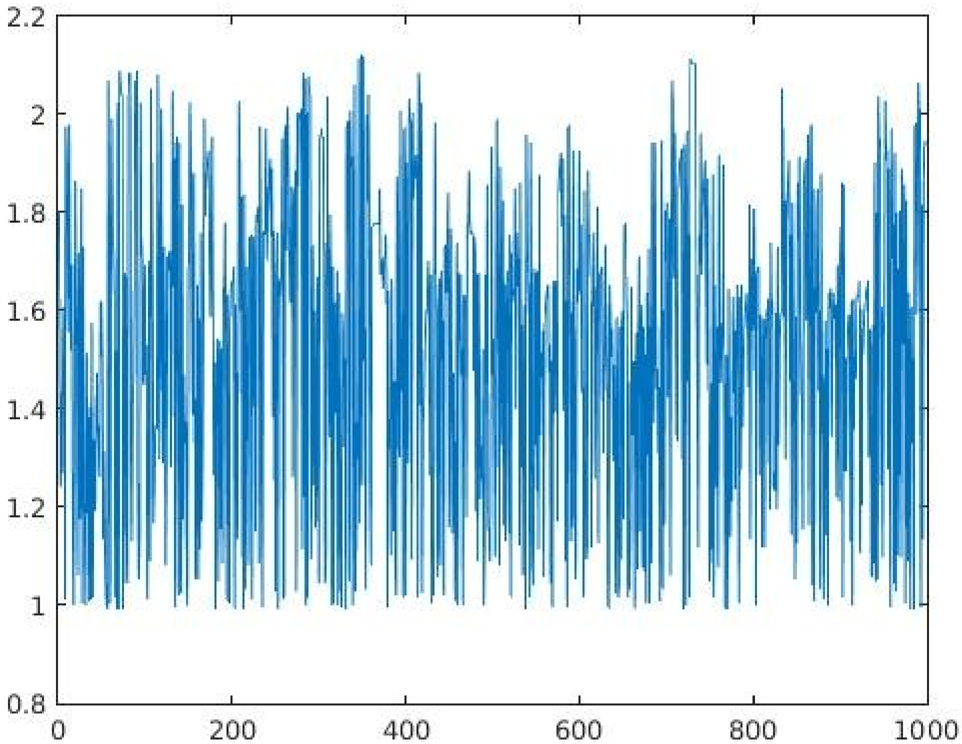
MSE curves for different channel models using 2 hidden layers

a) $y(n) = x(n) + 0.5x(n-1) + N(n)$
b) $y(n) = 0.5x(n) + x(n-1) + N(n)$
c) $y(n) = 0.364x(n) + 0.86x(n-1) + 0.364x(n-2)$

a)


2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0
200
400
600
800
1000

b)


2.2
2
1.8
1.6
1.4
1.2
1
0.8
0
200
400
600
800
1000

c)