

Mukhil Azhagan Mallaiyan Sathiaseelan

Project 1

Echo Cancellation

MATLAB CODE

Question A

PART 1

```
%%% Mukhil Azhagan Mallaiyan Sathiaseelan
%%% Project 1 Question A part 1

clc
clear all
close all
%%% Importing dataset
train=dlmread('music.txt');
corrupted=dlmread('corrupted_speech.txt');
desired=corrupted;
fs=22000;

N=length(train);
index2=1;
%%% define the step sizes u want
steps=[0.01 0.005 0.0025 0.001 0.0005];
for step=steps
    index1=1;
    for M=5:5:100

        %%%Defining and creating x matrix
        x=zeros(N-M+1,M);
        for j=1:M
            x(:,j)=train( j : N-M+(j) );
        end

        %%% Defining and creating d matrix
        d=zeros(N-M+1,1);
        d=desired(M:N,1);
        %%% Defining weight
        w=zeros(N-M+1,M);

        % Defining y and e and yexp and er
        y=zeros(N-M+1,1);
        e=zeros(N-M+1,1);
```

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for i=1:N-M+1
    y(i,1)=sum(x(i,:).*w(i,:));

    e(i,1)=d(i,1)-y(i,1);

    if i<N-M+1
        w( i+1 , : ) = w( i , : ) +2*step * e(i,1) .* x( i , : ) ./ ( x( i , :
    ) * x( i , : )' ) ;
    %     w( i+1 , : ) = w( i , : ) +2*step * e(i,1) .* x( i , : ) ;
    end

end

%%% Calculating ERLE
erle(index1,index2)=10*log10( ( norm(d)^2) / ( norm(e)^2));

%%% iterating index1
index1=index1+1;

fprintf(' iteration %d for %d taps \n',index1-1,M)

end
index2=index2+1;
end

%%% Plotting and converting to string to make a legend
strstep=num2str(steps');
plot(5:5:100,erle);
legend(strstep)
title('Ques A.1 ERLE plot vs M');
xlabel('Taps M')
xticks(5:5:100)
ylabel('Erle')
grid on;

%%% Plotting 3D surface plot
figure
steps1=log10(steps);
surf(steps,5:5:100,erle)
title('ERLE plot vs M and step size');
xlabel('step size')
ylabel('Taps (M)')
yticks(5:10:100)
grid on;

```

PART 2

```
%%% Mukhil Azhagan Mallaiyan Sathiaselvan
%%% Project 1 Question A part 2
clc
clear all
close all
%%% Importing dataset
train=dlmread('music.txt');
corrupted=dlmread('corrupted_speech.txt');
desired=corrupted;
fs=22000;

M=40;
N=length(train);
index=1;
w=zeros(N-M+1,M);

%%% as a bonus , changing the index will change the epochs
for index=1:1

    steps=[0.01 0.001 0.0001 0.00001];

    for step=steps

        %%% Defining and creating x matrix
        x=zeros(N-M+1,M);
        for j=1:M
            x(:,j)=train( j : N-M+(j) );
        end

        %%% Defining and creating d matrix
        d=zeros(N-M+1,1);
        d=desired(M:N,1);

        % Defining y and e and yexp and er
        y=zeros(N-M+1,1);
        e=zeros(N-M+1,1);

        %%% Adapting
        for i=1:N-M+1
            y(i,1)=x(i,:)*w(i,:)' ;
            e(i,1)=d(i,1)-y(i,1);

            if i<N-M+1
                w( i+1 , : ) = w( i , : ) + step * e(i,1) .* ( x( i , : ) )./
                ( x( i , : ) * x( i , : )' );
            end
        end
    end
end
```

```

    %% Plotting weight tracks
    figure
    for k=1:M
        plot(1:N-M+1,w(:,k));
        title(['Ques A.2 Weight tracks for step' num2str(step) ]);
        xlabel('samples')
        ylabel('weights')
        grid on;
        hold on;
    end

    %%% Enable this for learning curve
    % figure;
    % plot(1:N-M+1,(e.^2)./M);
    % title(['Ques A.2 learning curve for step' num2str(step) ]);
    % xlabel('samples')
    % ylabel('squared error')
    % grid on;

    step;
    index;
end

%% updating weights if there are multiple epochs
w(1,:)=w(N-M+1,:);
end

```

QUESTION B

PART 1

```

%% Mukhil Azhagan Mallaiyan Sathiaseelan
%% Project 1 Question B part 1

clc
clear all
close all
%% Importing dataset
train=dlmread('music.txt');
corrupted=dlmread('corrupted_speech.txt');
desired=corrupted;

fs=22000;
N=length(train);

```

```

index2=1;

%%% Define step sizes
steps=[0.01 0.001 0.0001];
for step= steps
index1=1;
for M=2:1:40

%Defining and creating x matrix
x=zeros(N-M+1,M);
%%% defining mu , the feedback parameter
mu=0.2;

%%%%%% creating input data
for j=1:M
    x(:,j)=train( j : N-M+(j) );
end
for i=1:N-M+1
    for j=2:M
        x(i,j)=(1-mu)*x( max( i-1,1 ),j)+mu*x( max( i-1,1 ),j-1);
    end
end
%%%%%%%%

%Defining and creating d matrix
d=zeros(N-M+1,1);
d=desired(1:N-M+1,1);
% Defining step size and weight
w=zeros(N-M+1,M);

for i=1:N-M+1
    y(i,1)=sum(x(i,:).*w(i,:));
    e(i,1)=d(i,1)-y(i,1);
    %%% to overcome the case when
    if i<N-M+1
        w( i+1 , : ) = w( i , : ) + step * e(i,1) .* x( i , : )./ ( x( i , : ) * x(
i , : )' ) ;
    end

end

%%% computing ERLE
erle(index1,index2)=10*log10( ( norm(d)^2) / ( norm(e)^2));

index1=index1+1;

%%% Plotting Weight tracks if needed
% figure;
% for k=1:M
% plot(1:N-M+1,w(:,k));
% title(['Ques B.1 Weight tracks for M' num2str(M) ]);

```

```

% xlabel('sample')
% ylabel('weights')
% grid on;
% hold on;
% end

fprintf(' iteration %d for %d taps \n',index1,M)

end
%%% for reference and debugging
step
index2=index2+1;
end

%%% 2d ERLE Plot vs M
strstep=num2str(steps');
figure;
plot(erle);
legend(strstep);
title('Ques B.1 ERLE plot vs M');
xlabel('Filter order M')
xticks(2:2:40)
ylabel('Erle')
grid on;

%%% ERLE surface plot ,note its in log for visual ease
figure
steps1=log10(steps);
surf(steps1,2:1:40,erle)
title('ERLE plot vs M and step size');
xlabel('log10 of step size')
ylabel('Taps (M) ')
yticks(2:4:40)
grid on;

```

PART 2

```

%%% Mukhil Azhagan Mallaiyan Sathiaselvan
%%% Project 1 Question B part 2

clc

```

```

clear all
close all
%%%% Importing dataset
train=dlmread('music.txt');
corrupted=dlmread('corrupted_speech.txt');
desired=corrupted;

M=30;
fs=22000;
N=length(train);

%% these are just for reference and allocating values
index1=1;
index2=1;
%% change the steps here
steps=[ 0.01 0.001 0.0001 ]

for step=steps
    index1=1;
    for mu=0.1:0.05:0.9

        %%%%% Defining and creating x matrix
        x=zeros(N-M+1,M);
        for j=1:M
            x(:,j)=train( j : N-M+(j) );
        end
        for i=1:N-M+1
            for j=2:M
                x(i,j)=(1-mu)*x( max( i-1,1 ),j)+mu*x( max( i-1,1 ) ,j-1);
            end
        end
        %%%%%%

        %Defining and creating d matrix
        d=zeros(N-M+1,1);
        d=desired(1:N-M+1,1);
        % Defining weight
        w=zeros(N-M+1,M);

        %%%% Adapting
        for i=1:N-M+1
            y(i,1)=sum(x(i,:).*w(i,:));
            e(i,1)=d(i,1)-y(i,1);

            if i<N-M+1
                w( i+1 , : ) = w( i , : ) + step * e(i,1) .* x( i , : ) ./ ( x( i , : ) * x(
i , : )' );
            end
        end

        end

erle(index1,index2)=10*log10( ( norm(d)^2 ) / ( norm(e)^2));
index1=index1+1;

```

```

%%% Plotting weight tracks if needed
% figure;
% for k=1:mu
% plot(1:N-M+1,w(:,k));
% title(['Ques B.1 Weight tracks for mu' num2str(mu)]);
% xlabel('sample')
% ylabel('weights')
% grid on;
% hold on;
% end

```

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end
%%% these are for reference and debugging purposes
step
index2=index2+1;
end

```

```

%%% 2d ERLE Plot vs mu
strstep=num2str(steps');
figure;
plot(0.1:0.05:0.9,erle);
legend(strstep);
title('Ques B.2 ERLE plot vs mu');
xlabel('mu')
xticks(0.1:0.1:0.9)
ylabel('Erle')
grid on;

```

```

%%% ERLE surface plot vs mu and stepsize
figure
strstep=num2str(steps');
surf(steps,0.1:0.05:0.9,erle);
title('Ques B.2 ERLE plot vs mu');
xlabel('step size')
ylabel('mu')
yticks(0.1:0.1:0.9)
zlabel('Erle')
grid on;

```