Digital Signal Processing

Special Assignment **Date :- 20 / 04 / 2024**

Term Assignment - 2

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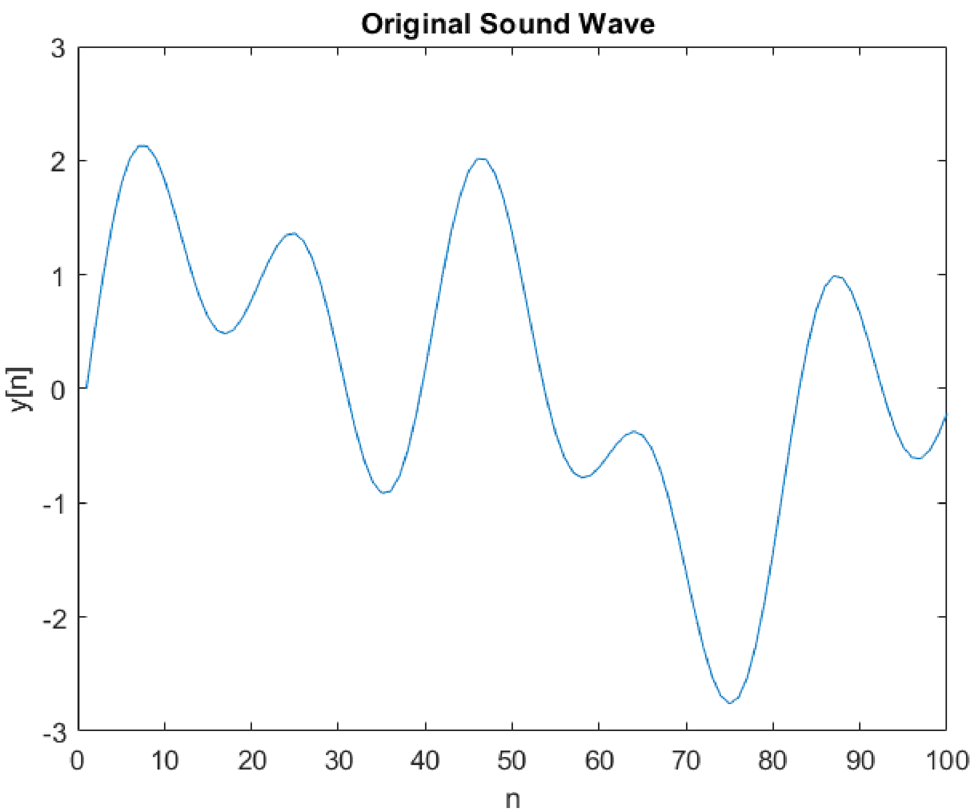
Topic :- Echo Removal using MATLAB

Problem Description :- To remove echo from audio signals using MATLAB to improve audio quality by implementing algorithms such as adaptive filtering or convolution . The goal is to enhance the clarity of the recorded signal by reducing or eliminating echo , with evaluating metrics including SNR improvement and subjective audio quality assessment .

Algorithm / MATLAB Code :-

```
load mtlb % This can be any audio file (.wav) file
Fs = 8000 ; % Sampling Frequency
%soundsc(mtlb , Fs)
```

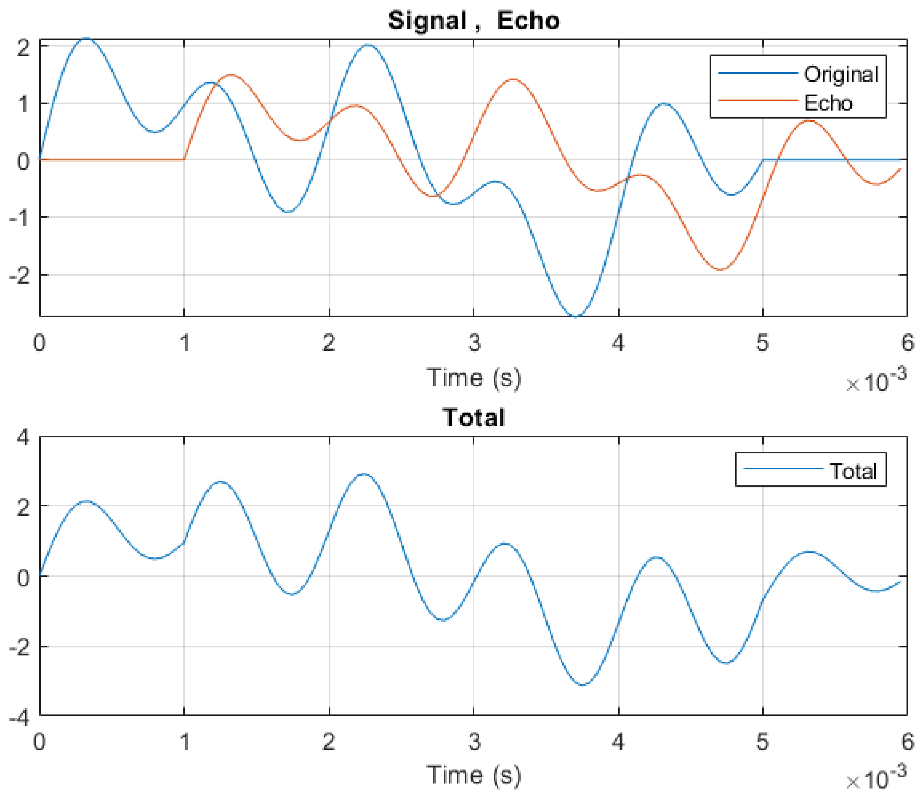
```
clc ; clear all ; close all ;
Fs = 20000 ;
N = 100 ;
t = 0 : 1/Fs : (N-1)/Fs ;

y = sin (2 * pi * 200 * t ) + sin (2 * pi * 500 * t) + sin (2 * pi * 1000 * t) ;
plot(y) ; title("Original Sound Wave ") ; ylabel("y[n]") ; xlabel("n") ;
```



y(n) = x(n) + αx(n−Δ)

Here , delta is **Delayed Samples** and alpha is **Attenuation Factor .**

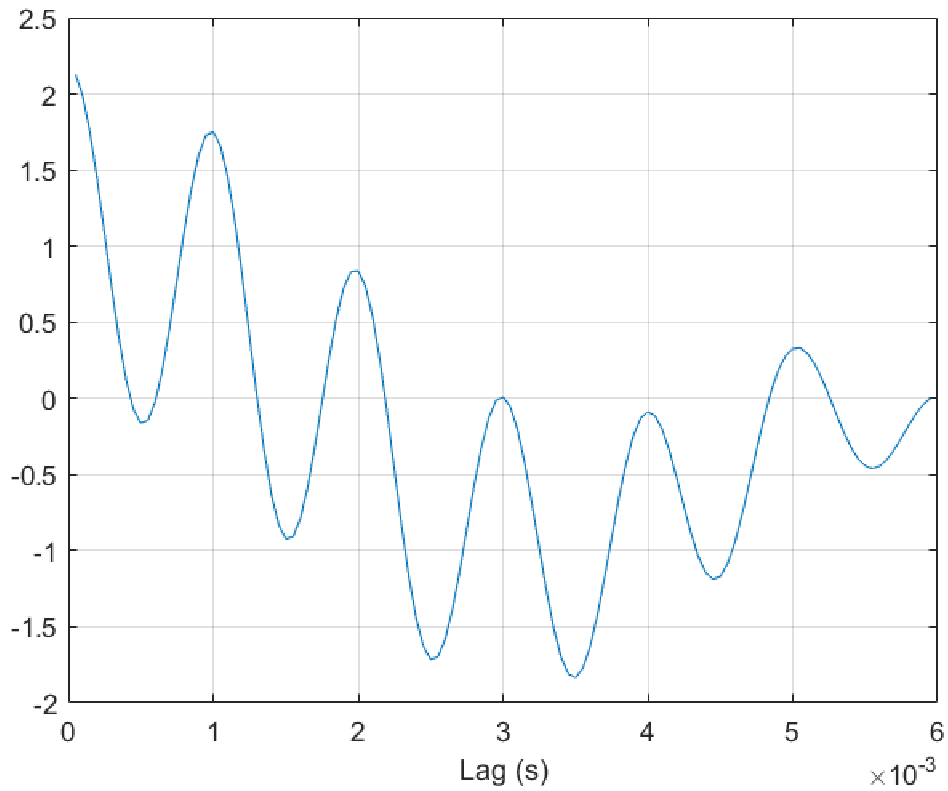
```
Fs = 20000 ; td = 0.001 ; delta = round(Fs * td) ; alpha = 0.7 ;

original = [y  zeros(1 , delta) ] ;
echo = [zeros(1 , delta)  y] * alpha ;

len = max(length(original)  , length(echo)) ;

original =[original zeros(1 , len - length(original))] ; echo = [echo zeros(1 , len
- length(echo))] ;
Final = original + echo ;

t1 = (0 : len - 1 ) / Fs ;

subplot(2,1,1) ; plot(t1 , [original ; echo]) ;
legend("Original","Echo") ; xlabel("Time (s)") ; title ("Signal ,  Echo") ; grid on
;
subplot(2,1,2) ; plot(t1 , Final) ;
legend("Total") ; xlabel("Time (s)") ; title ("Total") ; grid on ;
```



From the above chunk of code , we generated the **Final signal with Echo** . This process includes **Delaying** the Original Signal and **Attenuating** it and then **Adding** it with the Original Signal .

Now , we start to find the **Autocorrelation** using **xcorr() function** and further calculate **Lags** for different samples .

```
[R,lag] = xcorr(Final , "unbiased") ;

R = R(lag > 0) ;
lag = lag(lag > 0) ;

figure ;
plot(lag/Fs , R) ; xlabel("Lag (s)") ; grid on ;
```

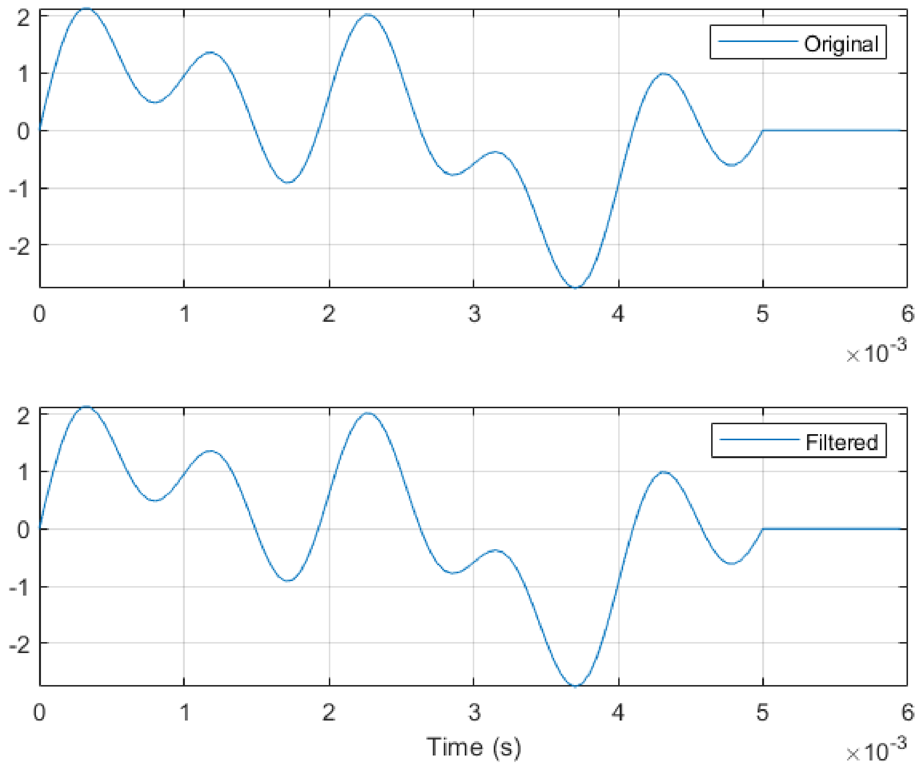


Here , from the curve we get the **Idea** that **Peaks are an indication** of **Echo arrival** .

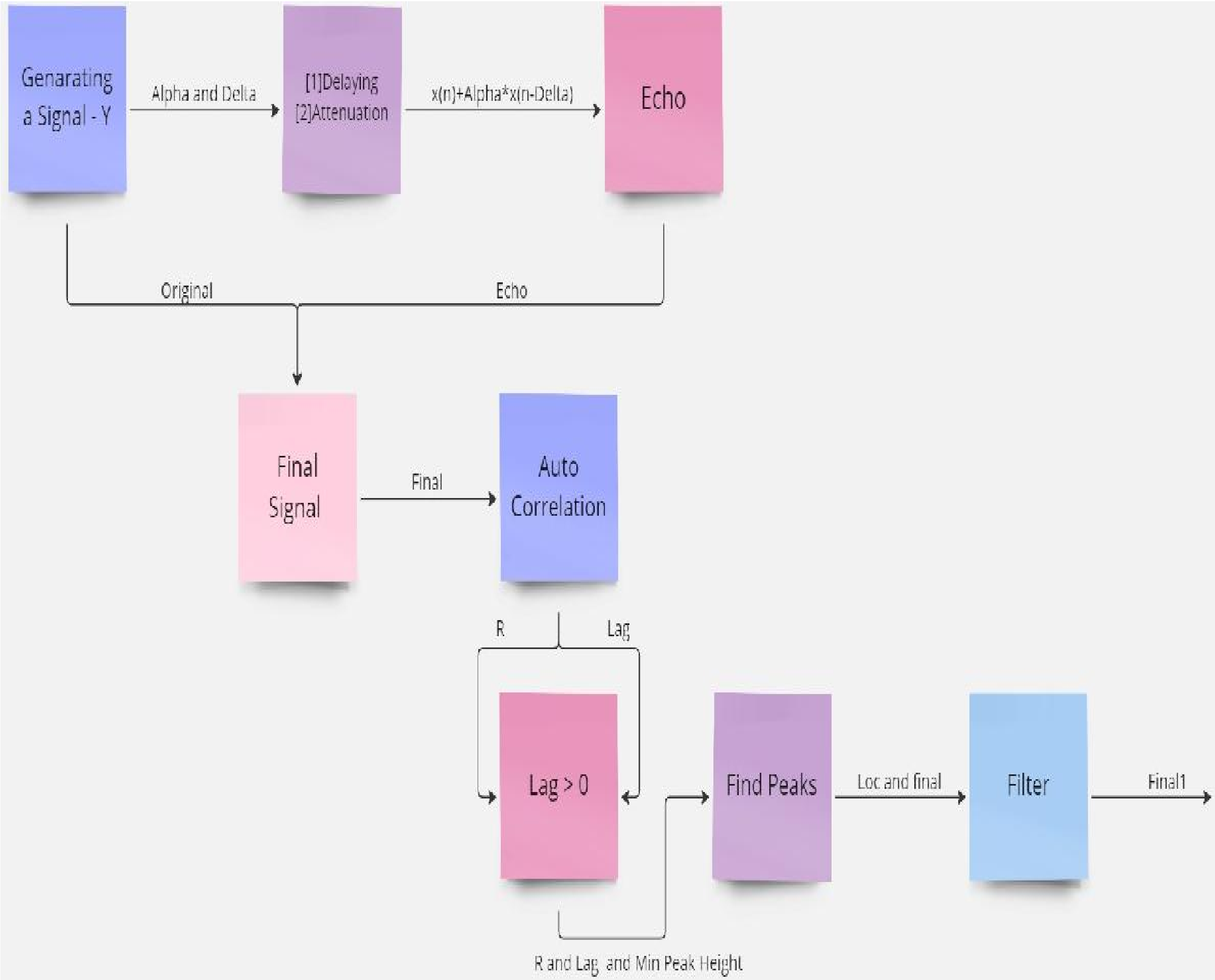
Now , we find the **Peaks** to remove the Echo that was introduced .Further , we cancel the **Echo** by filtering the Signal by an IIR Filter followed by the equation :-

w(n) + αw(n−Δ) = y(n).

```
[~ , loc] = findpeaks(R  , lag , 'MinPeakHeight', 0.5) ;

Final1 = filter(1 , [1 zeros(1 , loc(1) - 1) alpha] , Final) ;

subplot(2,1,1) ; plot(t1 , original) ; legend("Original") ; grid on ;

subplot(2,1,2) ; plot(t1 , Final1) ; legend("Filtered") ; xlabel("Time (s)") ; grid
on ;
```



Finally , we **removed the Echo** that was generated earlier . Similarly we can use the above algorithm to remove Echo in **Real Life Scenarios** .



Observations :- 1) We can clearly see that **echo signal was noticeable** in the signal .

2) Filtering effective **suppressed echo components** .

3) From this experiment , we learnt how to cancel echo components from the original signal and apply the **same algorithm for any recorded signal .**

Conclusion :- This experiment successfully demonstrated the **need for Echo Removal** , and sets the stage for **Adaptive Echo Removal Algorithms** . We can also further refine our results for a recorded signal as well and further **increase efficiency** with Adaptive Echo Filtering .