DIGITAL SIGNAL PROCESSING SIMULATION ASSIGNMENT

B SIVA DATTA -17EC10010

DAIVEEK SAI P-17EC10011

VAMSI KRISHNA M-17EC10029

V THEEDA ROHITH-17EC10058

ABHILAASH REDDY NARAPUREDDY-17EC30024

AIM:

TO FIND AN ALGORITHM THAT ALLOWS ONLY A PARTICULAR TO BE ABLE TO OPEN THE LOCK BY UTTERING A SEQUENCE .TO OBTAIN THE BEST FALSE ACCEPTANCE AND FALSE REJECTION RATIO.

Procedure:

- Load the speech files (sampled at 8KHz) into matlab.
- Plot the spectrum of each audio file.
- Pass the audio signal into 20 equi spaced filters each of size 400Hz.
- Record the energy of the signal which is getting out of every filter and construct the energy vector.

- Then, normalize the energy vector (so that we can compare energy vectors of every speech file with others).

- Now, construct a matrix of size NxN (N denoting the number of speech signals) each row containing the euclidean distance of its energy signal with every other vector.

CODE:

```
//low pass filter(equispaced)
h = zeros([No,N]);
for i = 1:No
h(i,1:N) = mysincB(pi/(2*No),N,(2*i-1)*pi/(2*No)).*w3;        w
= linspace(-pi,pi,512);
H=freqz(h(i,1:N),1,w);
hold on;
 plot(w,abs(H)); end
```

```
// Half filters spaced between 0-1KHz and rest between 1-3KHz for i = (No/2)+1:No
 h(i,1:N) = mysincB(3*pi/(4*No),N,pi/4+(2*(i-No/2-1)+1)*pi*3/(4*No)).*w5;
 w = linspace(-pi,pi,512);
 H=freqz(h(i,1:N),1,w);
 plot(w,abs(H));
end

function [h]=mysincB(wc,N,w)
k=(N-1)/2;
 for n=1:k
    m=n-1;
 h(n)=2*(sin((wc)*(m-k))/(pi*(m-k)))*cos(w*(m-k));
  end
  for n=k+2:N
   m=n-1;
   h(n)=2*(sin((wc)*(m-k))/(pi*(m-k)))*cos(w*(m-k));
     end
```

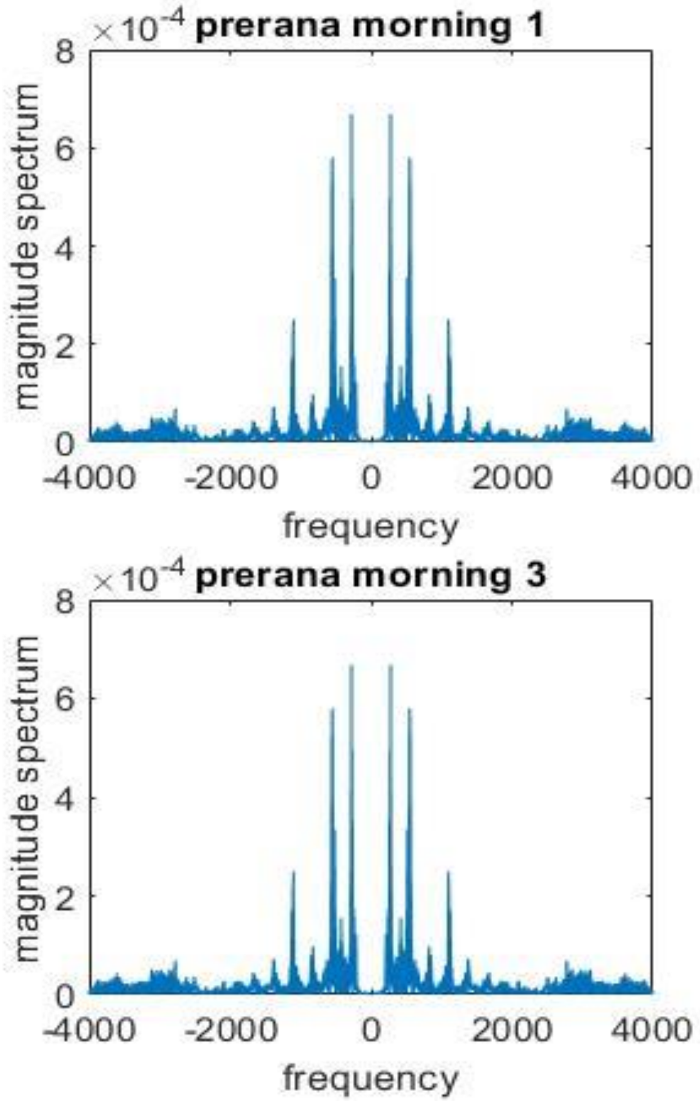
```
for n=k+2:N
m=n-1;
 h(n)=2*(sin((wc)*(m-k))/(pi*(m-k)))*cos(w*(m-k));
end
h(k+1)=2*wc/pi;
end


//signal energy function
 [y] = sigeng(x)
 z = x.*x;
 y = sum(z);
 end
  eng = zeros([length(voices),No]);
   for i=1:length(voices)
   [s,Fs] = audioread(char(voices(1,i)));
   y = zeros([No,N+length(s)-1]);
    for j = 1:No
```

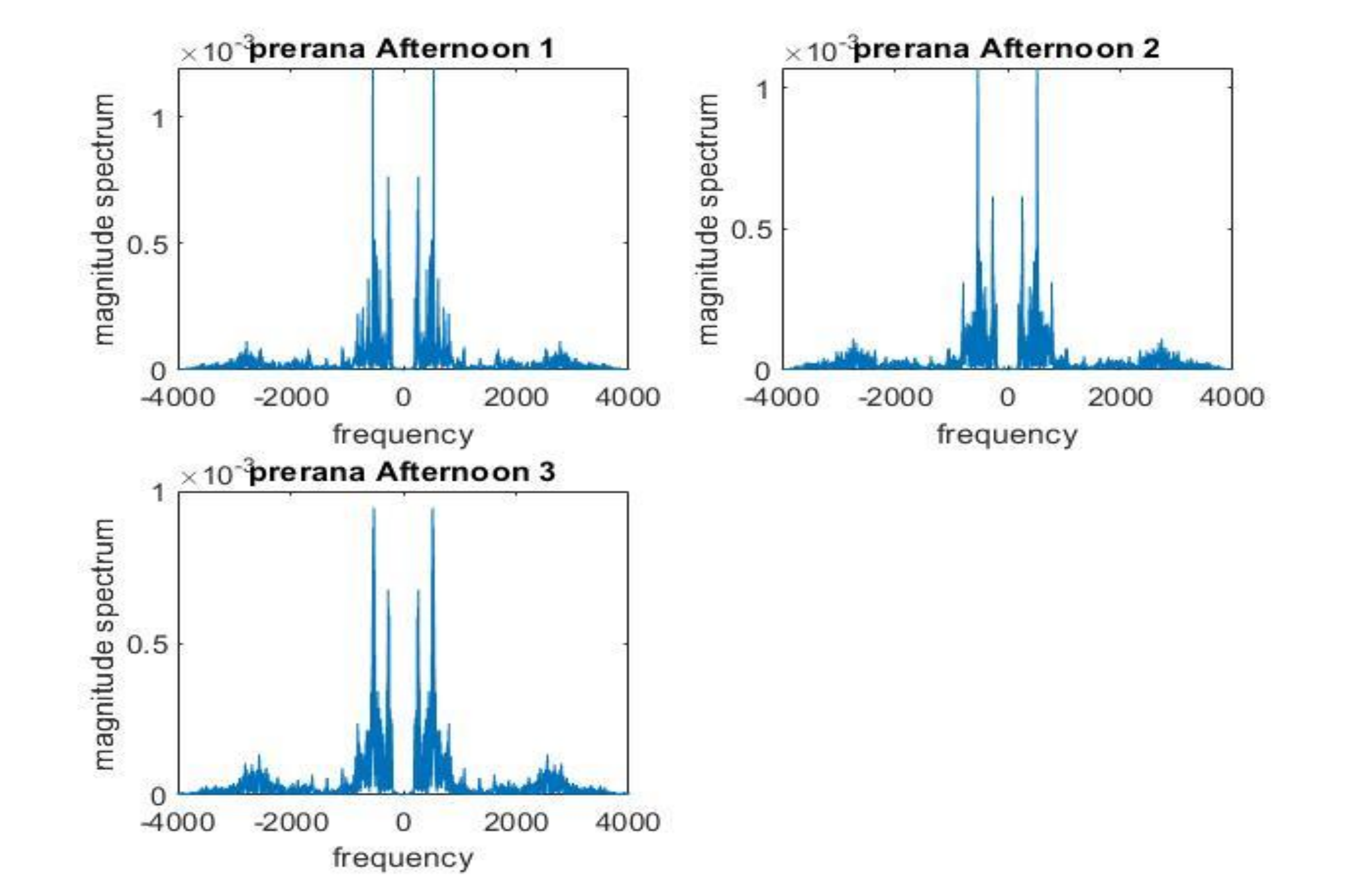
```
y(j,1:N+length(s)-1) = conv(h(j,1:N),s);
End
for j = 1:No
   eng(i,j) = sigeng(y(j,1:N+length(s)-1))/sigeng(s);
     end
 end
```

We calculated the distance between the energy vectors using two distance measures(Euclidean distance and log spectral distance)

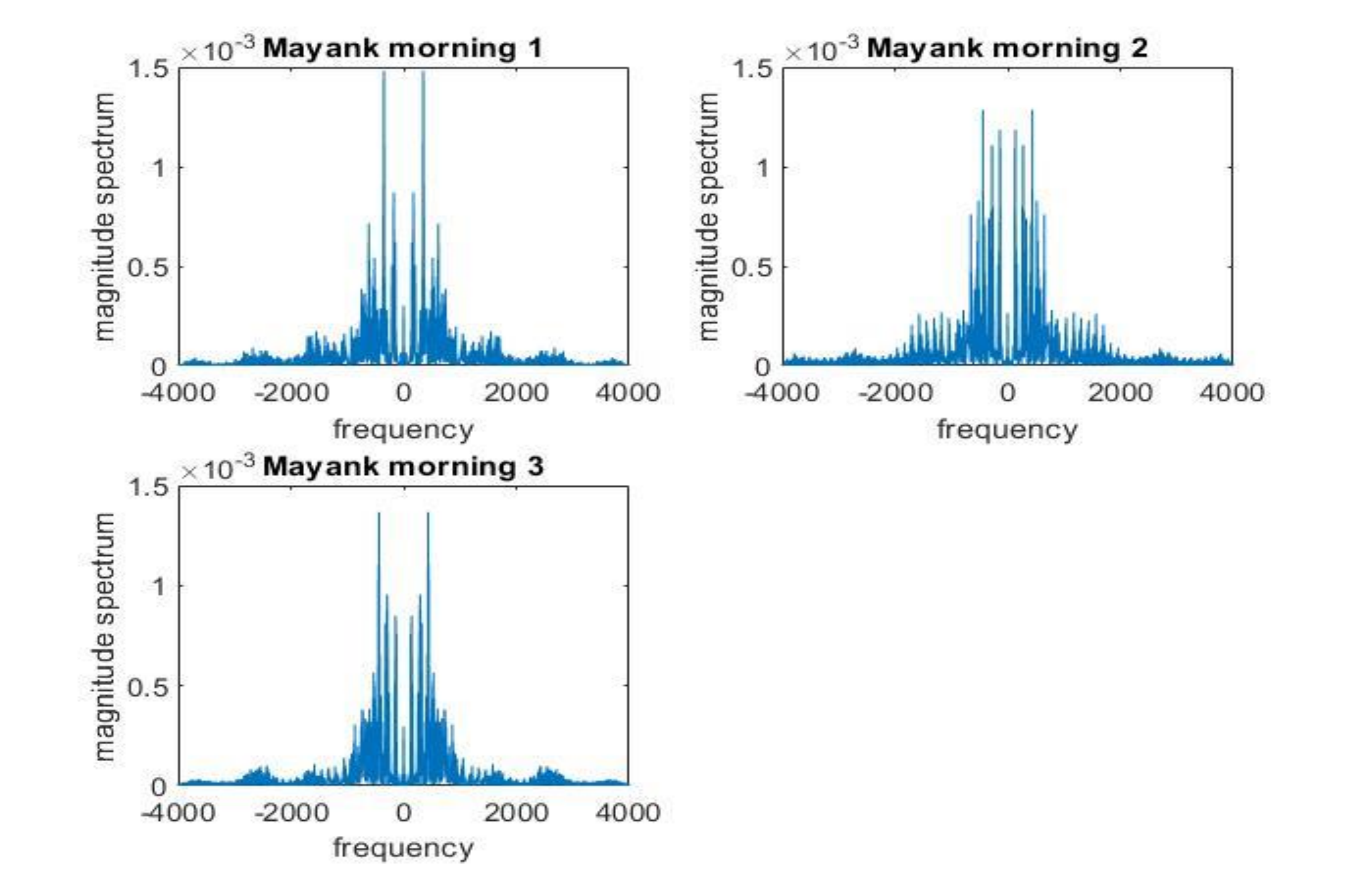
Frequency Response of Prerana's Speech Signal



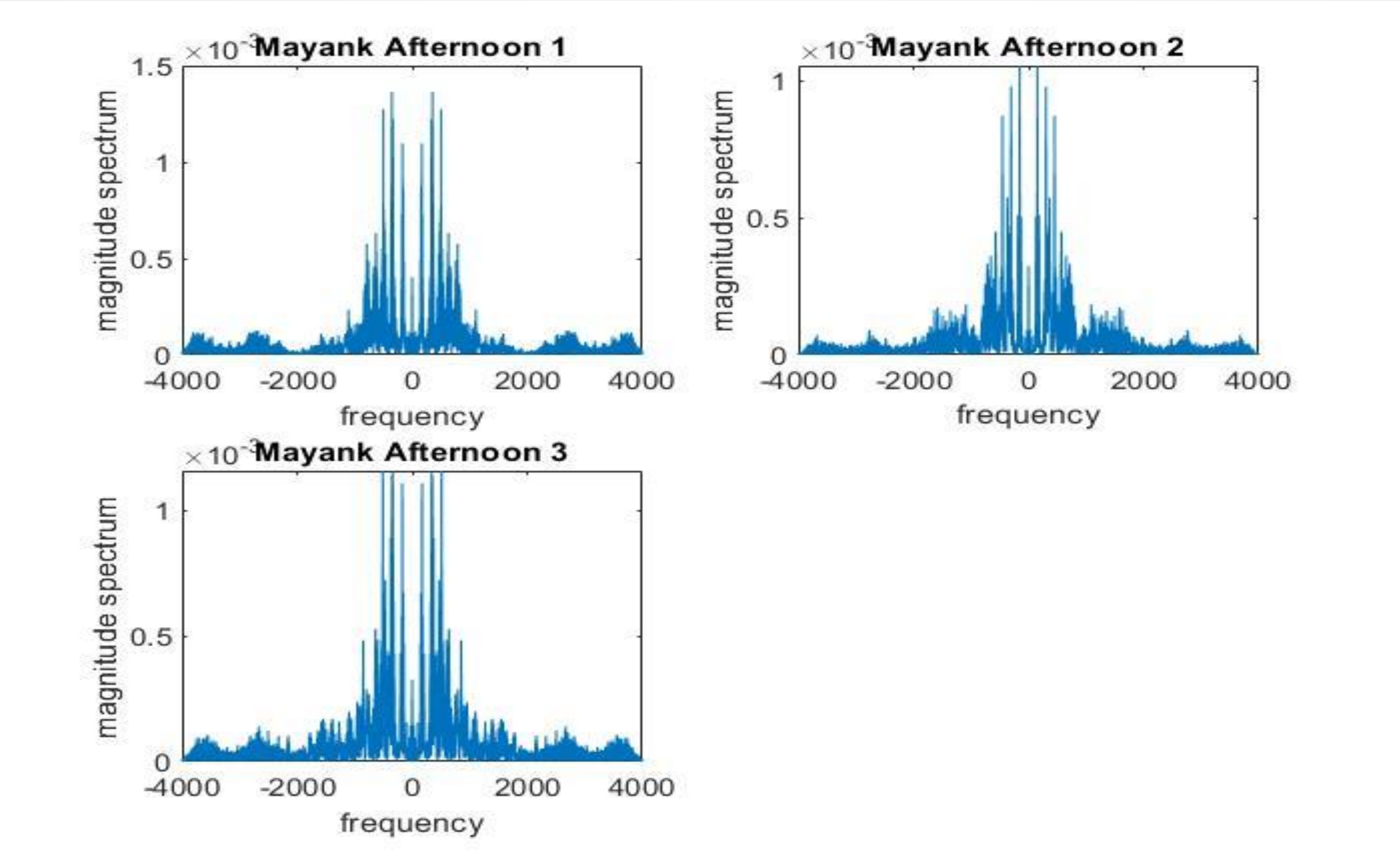
Frequency Response of Prerana's Speech Signal



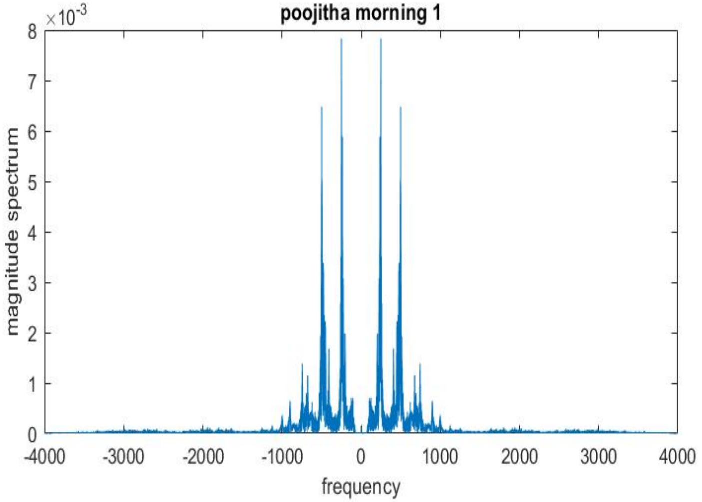
Frequency Response of Mayank's Speech Signal

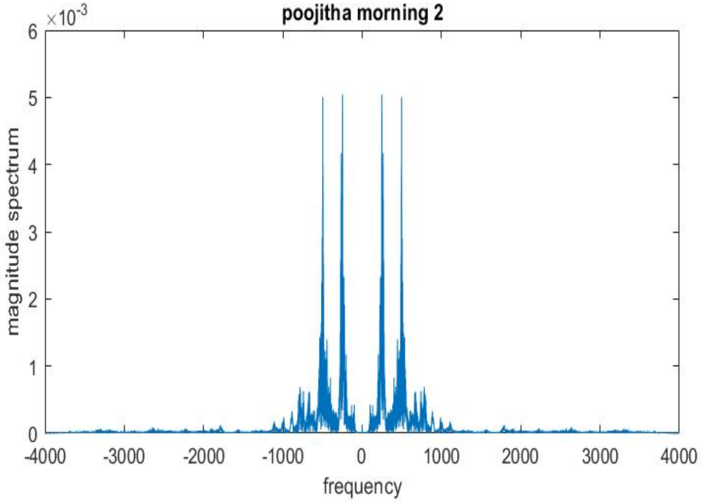


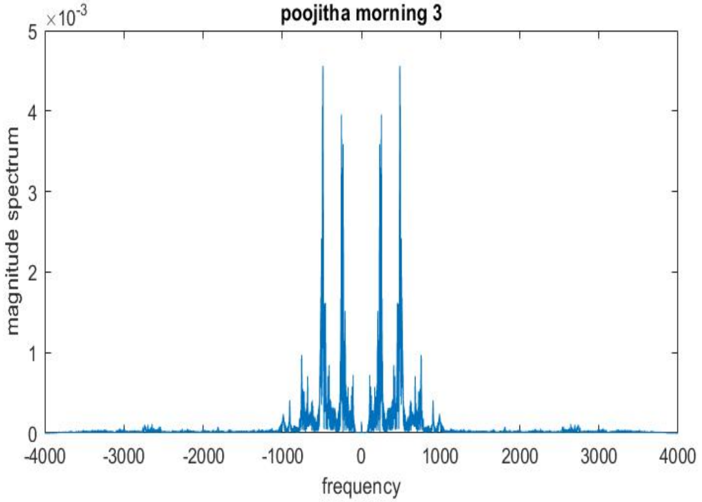
Frequency Response of Mayank's Speech Signal



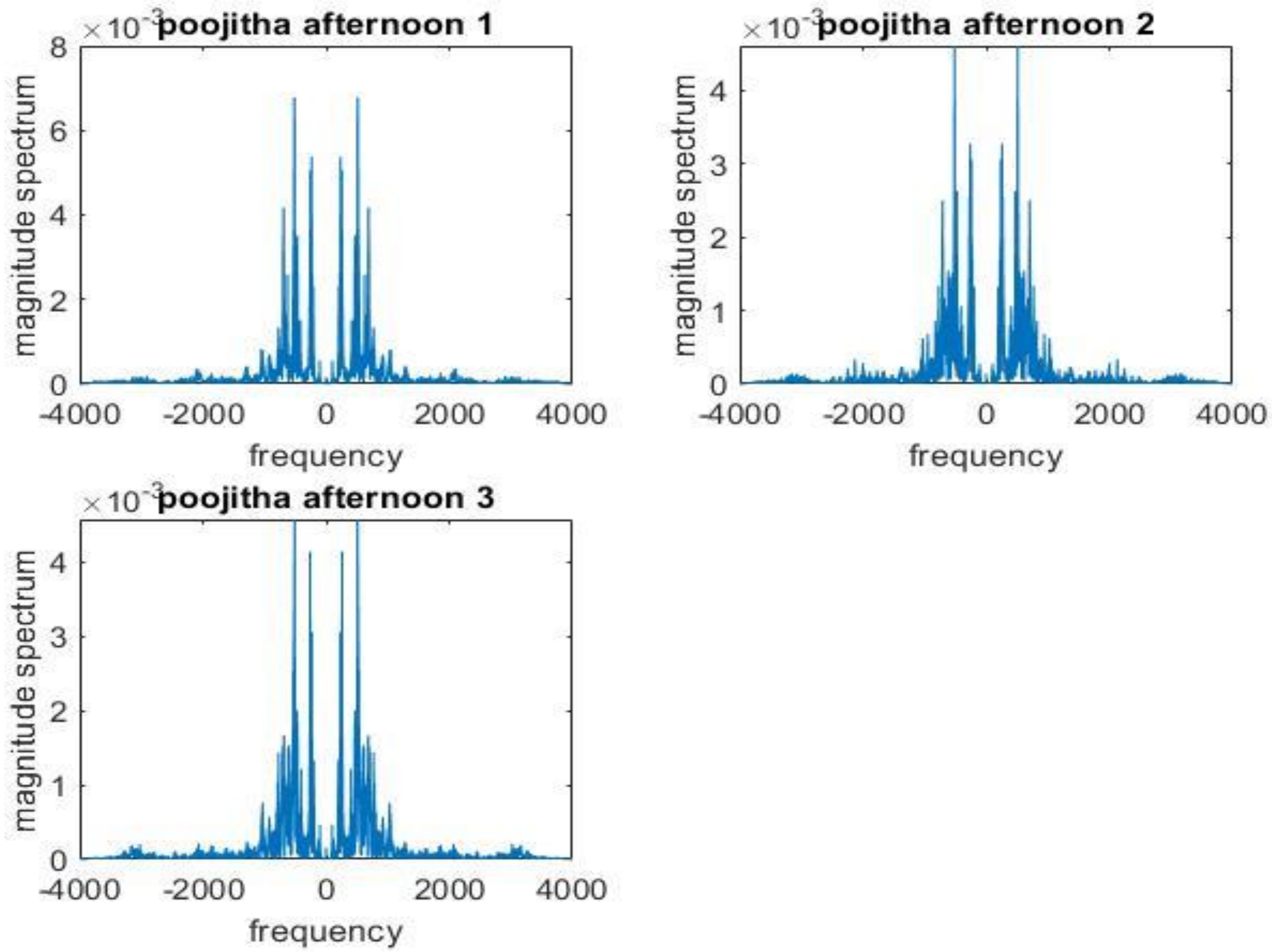
Frequency Response of Poojitha's Speech Signal



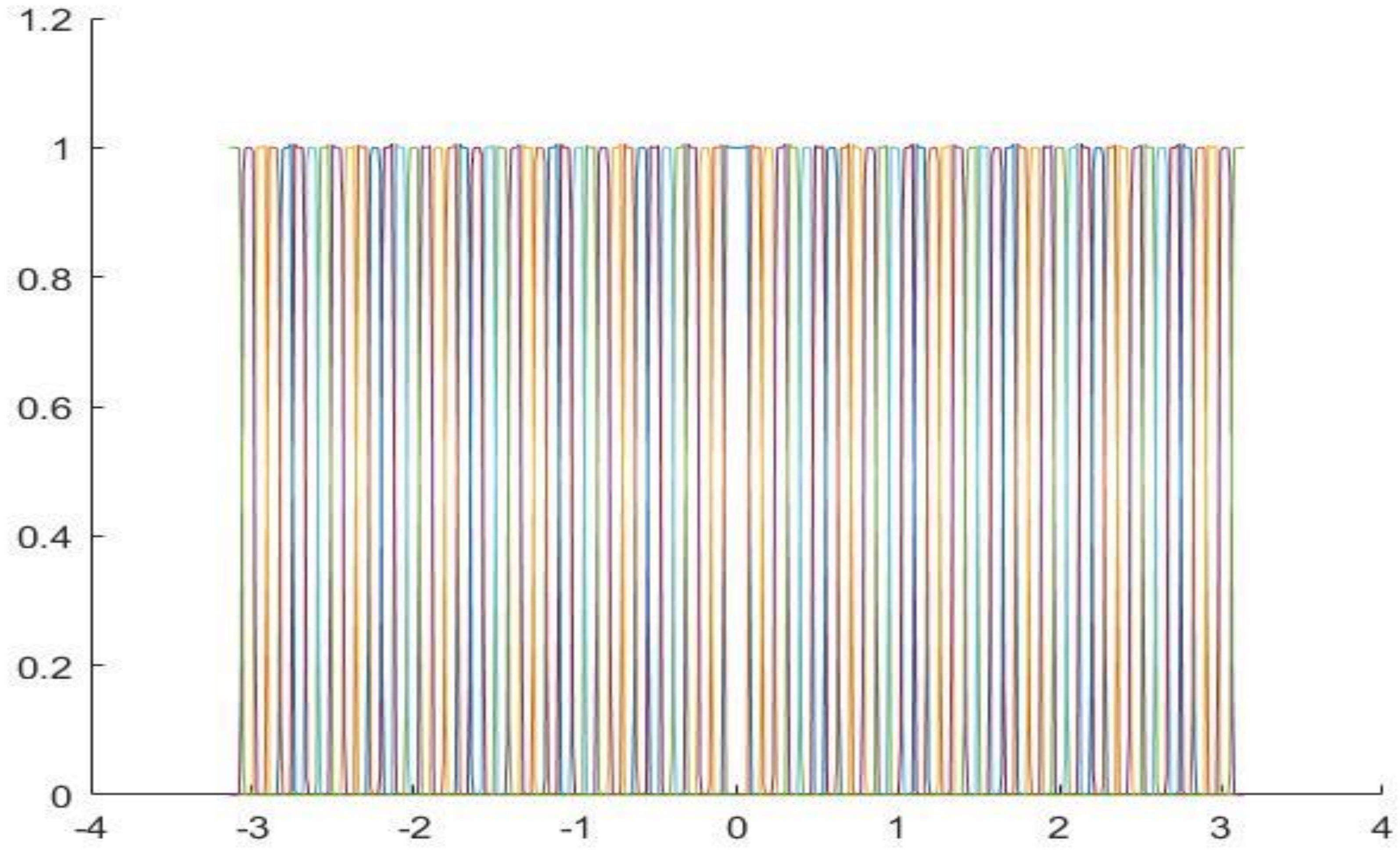




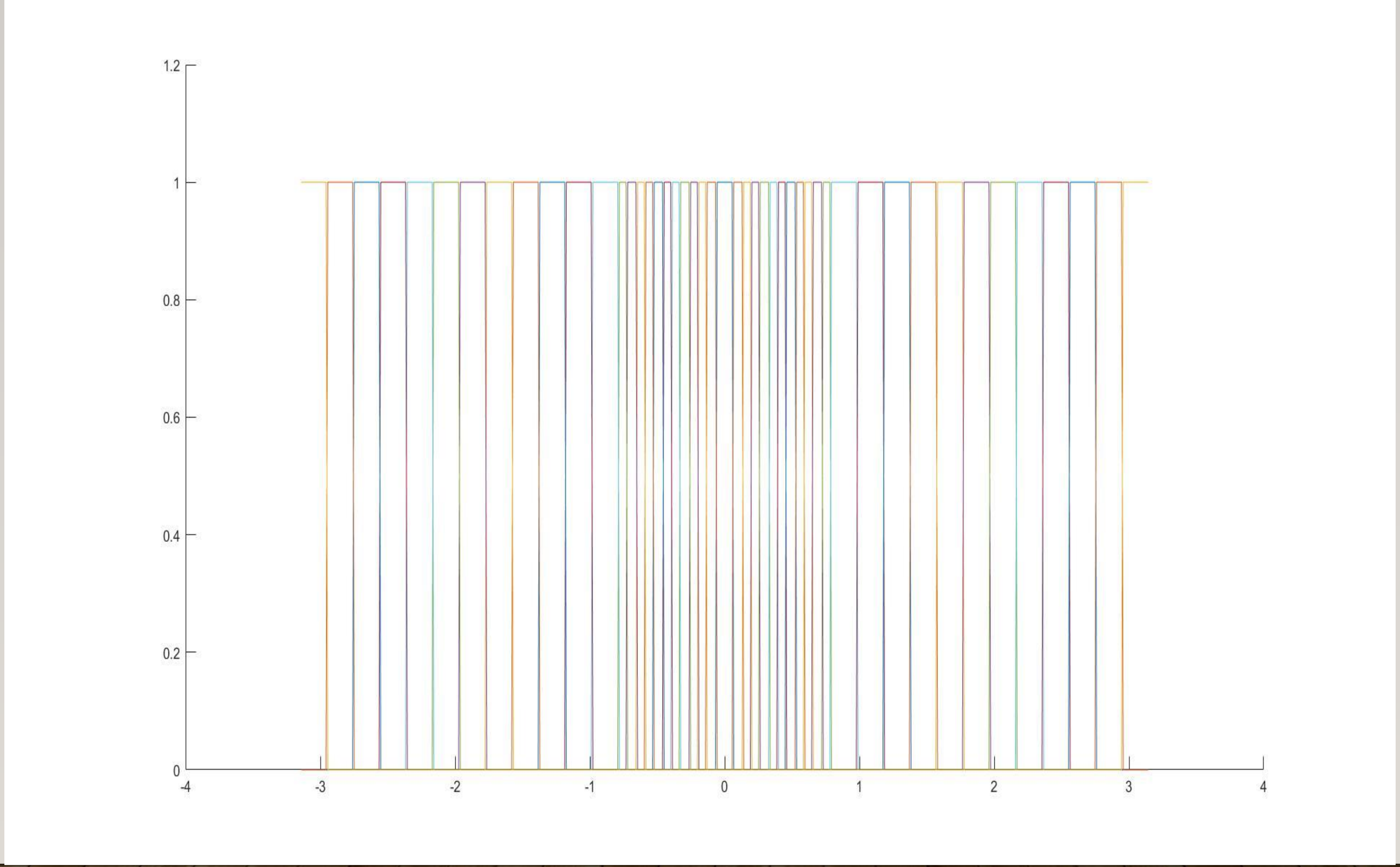
Frequency Response of Poojitha's Speech Signal



20 Equispaced filters of 400Hz are designed in frequency range of 0-4KH



Half filters spaced between 0-1KHz and rest between 1-4KHz



Distances matrix when using 20 equal bandwidth filters

MATLAB R2016b - academic use

Variables - dist

18x18 double

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	0	0.2120	0.2808	0.0684	0.1018	0.1497	0.4052	0.3398	0.4685	0.4783	0.4904	0.5042	0.3636	0.3647	0.4484	0.3607	0.3501	0.4207
2	0.2120	0	0.1113	0.1651	0.1462	0.0994	0.2481	0.2114	0.2909	0.3057	0.3140	0.3248	0.2817	0.2926	0.2965	0.2624	0.2372	0.2755
3	0.2808	0.1113	0	0.2251	0.2400	0.1759	0.1957	0.1714	0.2149	0.2098	0.2174	0.2325	0.2544	0.2687	0.2245	0.1696	0.1389	0.1697
4	0.0684	0.1651	0.2251	0	0.0962	0.1069	0.3570	0.2958	0.4154	0.4230	0.4349	0.4490	0.3348	0.3383	0.4034	0.3089	0.2969	0.3651
5	0.1018	0.1462	0.2400	0.0962	0	0.1176	0.3738	0.3215	0.4295	0.4442	0.4526	0.4656	0.3637	0.3687	0.4233	0.3551	0.3401	0.3971
6	0.1497	0.0994	0.1759	0.1069	0.1176	0	0.2804	0.2231	0.3440	0.3625	0.3779	0.3851	0.2676	0.2734	0.3306	0.3032	0.2787	0.3321
7	0.4052	0.2481	0.1957	0.3570	0.3738	0.2804	0	0.0888	0.0982	0.1592	0.1841	0.1739	0.1866	0.2013	0.1208	0.2565	0.2203	0.2082
8	0.3398	0.2114	0.1714	0.2958	0.3215	0.2231	0.0888	0	0.1659	0.2022	0.2278	0.2244	0.1345	0.1476	0.1427	0.2411	0.2040	0.2226
9	0.4685	0.2909	0.2149	0.4154	0.4295	0.3440	0.0982	0.1659	0	0.0812	0.0999	0.0847	0.2585	0.2749	0.1255	0.2492	0.2168	0.1694
10	0.4783	0.3057	0.2098	0.4230	0.4442	0.3625	0.1592	0.2022	0.0812	0	0.0373	0.0363	0.2851	0.3019	0.1418	0.2105	0.1817	0.1184
11	0.4904	0.3140	0.2174	0.4349	0.4526	0.3779	0.1841	0.2278	0.0999	0.0373	0	0.0387	0.3141	0.3310	0.1700	0.2121	0.1877	0.1160
12	0.5042	0.3248	0.2325	0.4490	0.4656	0.3851	0.1739	0.2244	0.0847	0.0363	0.0387	0	0.3049	0.3219	0.1535	0.2409	0.2134	0.1464
13	0.3636	0.2817	0.2544	0.3348	0.3637	0.2676	0.1866	0.1345	0.2585	0.2851	0.3141	0.3049	0	0.0181	0.1643	0.3191	0.2829	0.3098
14	0.3647	0.2926	0.2687	0.3383	0.3687	0.2734	0.2013	0.1476	0.2749	0.3019	0.3310	0.3219	0.0181	0	0.1808	0.3310	0.2956	0.3248
15	0.4484	0.2965	0.2245	0.4034	0.4233	0.3306	0.1208	0.1427	0.1255	0.1418	0.1700	0.1535	0.1643	0.1808	0	0.2687	0.2307	0.2109
16	0.3607	0.2624	0.1696	0.3089	0.3551	0.3032	0.2565	0.2411	0.2492	0.2105	0.2121	0.2409	0.3191	0.3310	0.2687	0	0.0416	0.0995
17	0.3501	0.2372	0.1389	0.2969	0.3401	0.2787	0.2203	0.2040	0.2168	0.1817	0.1877	0.2134	0.2829	0.2956	0.2307	0.0416	0	0.0832
18	0.4207	0.2755	0.1697	0.3651	0.3971	0.3321	0.2082	0.2226	0.1694	0.1184	0.1160	0.1464	0.3098	0.3248	0.2109	0.0995	0.0832	0

Distances matrix when using 12 equal bandwidth filters in 0-1000Hz and remaining between 1000-4000Hz

MATLAB R2016b - academic use

Variables - dist

18x18 double

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1		0.4212	0.4913	0.1515	0.3064	0.1270	0.5772	0.4797	0.5640	0.5222	0.5297	0.5568	0.5209	0.4995	0.5735	0.4453	0.4479	0.4723
2	0.4212	0	0.1654	0.3221	0.1488	0.3687	0.3984	0.2018	0.4114	0.3843	0.4243	0.4483	0.4726	0.3190	0.4339	0.3567	0.3397	0.3893
3	0.4913	0.1654	0	0.3783	0.2292	0.4433	0.4919	0.2271	0.4929	0.4516	0.4963	0.5228	0.4332	0.2884	0.3368	0.3992	0.4017	0.4564
4	0.1515	0.3221	0.3783	0	0.2145	0.1314	0.5280	0.3919	0.5163	0.4720	0.4864	0.5166	0.4839	0.4316	0.4959	0.4120	0.4101	0.4397
5	0.3064	0.1488	0.2292	0.2145	0	0.2845	0.4832	0.2876	0.4895	0.4560	0.4869	0.5153	0.4462	0.3436	0.4368	0.3854	0.3818	0.4345
6	0.1270	0.3687	0.4433	0.1314	0.2845	0	0.4891	0.4042	0.4718	0.4321	0.4390	0.4655	0.4906	0.4442	0.5268	0.3915	0.3852	0.4003
7	0.5772	0.3984	0.4919	0.5280	0.4832	0.4891	0	0.3010	0.0926	0.1729	0.1832	0.1821	0.6350	0.4694	0.6355	0.3219	0.2557	0.2457
8	0.4797	0.2018	0.2271	0.3919	0.2876	0.4042	0.3010	0	0.3116	0.2903	0.3371	0.3600	0.4251	0.2296	0.3840	0.2878	0.2641	0.3151
9	0.5640	0.4114	0.4929	0.5163	0.4895	0.4718	0.0926	0.3116	0	0.1011	0.0999	0.0980	0.6077	0.4620	0.6081	0.2791	0.2198	0.1873
10	0.5222	0.3843	0.4516	0.4720	0.4560	0.4321	0.1729	0.2903	0.1011	0	0.0652	0.0782	0.5482	0.4157	0.5470	0.2208	0.1686	0.1198
11	0.5297	0.4243	0.4963	0.4864	0.4869	0.4390	0.1832	0.3371	0.0999	0.0652	0	0.0400	0.5869	0.4637	0.5911	0.2412	0.1900	0.1353
12	0.5568	0.4483	0.5228	0.5166	0.5153	0.4655	0.1821	0.3600	0.0980	0.0782	0.0400	0	0.6061	0.4834	0.6129	0.2674	0.2166	0.1537
13	0.5209	0.4726	0.4332	0.4839	0.4462	0.4906	0.6350	0.4251	0.6077	0.5482	0.5869	0.6061	0	0.2222	0.1977	0.4358	0.4757	0.5036
14	0.4995	0.3190	0.2884	0.4316	0.3436	0.4442	0.4694	0.2296	0.4620	0.4157	0.4637	0.4834	0.2222	0	0.2225	0.3475	0.3593	0.4027
15	0.5735	0.4339	0.3368	0.4959	0.4368	0.5268	0.6355	0.3840	0.6081	0.5470	0.5911	0.6129	0.1977	0.2225	0	0.4654	0.4996	0.5307
16	0.4453	0.3567	0.3992	0.4120	0.3854	0.3915	0.3219	0.2878	0.2791	0.2208	0.2412	0.2674	0.4358	0.3475	0.4654	0	0.0754	0.1320
17	0.4479	0.3397	0.4017	0.4101	0.3818	0.3852	0.2557	0.2641	0.2198	0.1686	0.1900	0.2166	0.4757	0.3593	0.4996	0.0754	0	0.0962
18	0.4723	0.3893	0.4564	0.4397	0.4345	0.4003	0.2457	0.3151	0.1873	0.1198	0.1353	0.1537	0.5036	0.4027	0.5307	0.1320	0.0962	0

Pitch:

Pitch is the fundamental frequency(F0) of the vocal cords followed by 4-5 formants(F1-F5) at higher frequencies.

Pitch Detection Algorithm:

- Observing a speech signal spectrum it could be said that the first peak in the spectrum is the fundamental frequency and it can be called as the pitch.
- In some cases fundamental frequency of the vocal cord may not be present . In those cases pitch can be obtained by taking the difference between any two consecutive frequencies (F1-F5)

Method 2:

- Pitch can also be detected using autocorrelation function.
- By performing the normalized cross correlation of the speech signal with the sinusoidal signal in the frequency range of 50-500 Hz we can observe the peak at the pitch frequency.

Since every person will have a unique pitch this can be used to improve the voice detection algorithm.

Instead of Euclidean distance if we use log spectral distance the performance will increase below is the distance matrix using log spectral distance

19x19 double

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	0	3.3508	3.4207	5.3492	3.3143	3.8660	11.8351	9.3795	10.8483	10.7816	8.5553	8.7976	11.2358	11.6446	12.4774	9.8267	8.2967	9.1108
2	3.3508	0	3.6613	5.6625	3.1112	3.6910	10.2272	7.7492	9.5033	9.8829	7.6828	8.1088	10.8584	11.2953	12.2772	9.1723	7.7992	8.5132
3	3.4207	3.6613	0	5.4600	4.7087	4.9003	11.4855	8.8956	10.4142	9.7413	7.6164	7.6993	9.0045	9.4108	10.1498	8.6624	7.0730	7.7921
4	5.3492	5.6625	5.4600	0	4.4391	3.4351	11.8518	9.6385	11.2237	11.6869	9.2826	9.8678	12.9751	13.3827	13.8946	11.7022	10.4688	10.9297
5	3.3143	3.1112	4.7087	4.4391	0	2.7836	11.5122	8.8075	10.7348	11.3681	8.8478	9.6503	12.3985	12.8252	13.5290	10.7402	9.3564	10.0700
6	3.8660	3.6910	4.9003	3.4351	2.7836	0	10.8868	8.3679	10.1405	10.8029	8.3580	9.0156	12.7688	13.1481	13.9593	10.9238	9.5376	10.2314
7	11.8351	10.2272	11.4855	11.8518	11.5122	10.8868	0	4.7284	3.0535	5.8693	7.0889	7.1108	13.4058	13.2982	14.4203	9.6873	10.3274	10.3632
8	9.3795	7.7492	8.8956	9.6385	8.8075	8.3679	4.7284	0	3.0471	5.5118	4.6245	5.6246	12.4940	12.7211	13.5640	8.9277	8.9011	9.2991
9	10.8483	9.5033	10.4142	11.2237	10.7348	10.1405	3.0535	3.0471	0	4.8621	5.4536	5.8432	12.6816	12.7611	13.6026	8.6022	9.1590	9.3731
10	10.7816	9.8829	9.7413	11.6869	11.3681	10.8029	5.8693	5.5118	4.8621	0	4.3488	3.6391	10.3743	10.1980	11.4501	6.9263	7.3720	7.4690
11	8.5553	7.6828	7.6164	9.2826	8.8478	8.3580	7.0889	4.6245	5.4536	4.3488	0	2.3327	10.2733	10.3573	11.1620	7.4272	6.7545	7.3425
12	8.7976	8.1088	7.6993	9.8678	9.6503	9.0156	7.1108	5.6246	5.8432	3.6391	2.3327	0	9.7589	9.6400	10.7974	7.3172	6.7921	7.2556
13	11.2358	10.8584	9.0045	12.9751	12.3985	12.7688	13.4058	12.4940	12.6816	10.3743	10.2733	9.7589	0	2.1937	2.8500	6.6108	6.3523	5.9585
14	11.6446	11.2953	9.4108	13.3827	12.8252	13.1481	13.2982	12.7211	12.7611	10.1980	10.3573	9.6400	2.1937	0	3.3024	6.8323	6.4942	6.1376
15	12.4774	12.2772	10.1498	13.8946	13.5290	13.9593	14.4203	13.5640	13.6026	11.4501	11.1620	10.7974	2.8500	3.3024	0	7.9808	7.9316	7.5752
16	9.8267	9.1723	8.6624	11.7022	10.7402	10.9238	9.6873	8.9277	8.6022	6.9263	7.4272	7.3172	6.6108	6.8323	7.9808	0	3.2541	3.0651
17	8.2967	7.7992	7.0730	10.4688	9.3564	9.5376	10.3274	8.9011	9.1590	7.3720	6.7545	6.7921	6.3523	6.4942	7.9316	3.2541	0	2.4294
18		8.5132	7.7921	10.9297	10.0700	10.2314	10.3632	9.2991	9.3731	7.4690	7.3425	7.2556	5.9585	6.1376	7.5752	3.0651	2.4294	0