DSP Lab Report

Experiment 3

Aim:

1. To find the fundamental frequency of different instruments using DFT.
2. To find two closely related instruments using fundamental frequency.
3. To find the fundamental frequency of the humming sound.
4. To capture the temporal variation of an Opera using frequency spectrum.
5. To check if the fundamental frequencies of two uttered vowels is similar.

Code:

Q1)

```
# a = 4

# for flute
[y,Fs] = audioread('flute4.wav');

# taking DFT
Fy = fft(y);

L = length(Fy);
N = length(y);

k = [0:L-1];

# getting frequencies
f = Fs/N .* k;

subplot(2,2,1);
plot(f,abs(Fy));
```

```
title('Flute4 - abs(DFT) VS Frequency');
xlabel('Frequency (Hz)');
ylabel('DFT(y(t))');

m = 1;
for i=[1:int16(L/2)]
  if Fy(m) < Fy(i)
    m = i;
  endif
endfor

disp('Flute4 -->');
disp('Fundamental frequency:');
disp(f(m));
disp('abs(DFT) at fundamental frequency:');
disp(abs(Fy(m)));


# for piano

[y,Fs] = audioread('piano4.wav');

# taking DFT
Fy = fft(y);

L = length(Fy);
N = length(y);

k = [0:L-1];
```

```
# getting frequencies
f = Fs/N .* k;

subplot(2,2,2);
plot(f,abs(Fy));
title('Piano4 - abs(DFT) VS Frequency');
xlabel('Frequency (Hz)');
ylabel('DFT(y(t))');

m = 1;
for i=[1:int32(L/2)]
  if Fy(m) < Fy(i)
    m = i;
  endif
endfor

disp('Piano4 -->');
disp('Fundamental frequency:');
disp(f(m));
disp('abs(DFT) at fundamental frequency:');
disp(abs(Fy(m)));


# for trumpet

[y,Fs] = audioread('trumpet4.wav');
```

```
# taking DFT
Fy = fft(y);

L = length(Fy);
N = length(y);

k = [0:L-1];

# getting frequencies
f = Fs/N .* k;

subplot(2,2,3);
plot(f,abs(Fy));
title('Trumpet4 - abs(DFT) VS Frequency');
xlabel('Frequency (Hz)');
ylabel('DFT(y(t))');

m = 1;
for i=[1:int32(L/2)]
  if Fy(m) < Fy(i)
    m = i;
  endif
endfor

disp('Trumpet4 -->');
disp('Fundamental frequency:');
disp(f(m));
disp('abs(DFT) at fundamental frequency:');
disp(abs(Fy(m)));
```

```
# for violin

[y,Fs] = audioread('violin4.wav');

# taking DFT
Fy = fft(y);

L = length(Fy);
N = length(y);

k = [0:L-1];

# getting frequencies
f = Fs/N .* k;

subplot(2,2,4);
plot(f,abs(Fy));
title('Violin4 - abs(DFT) VS Frequency');
xlabel('Frequency (Hz)');
ylabel('DFT(y(t))');

m = 1;
for i=[1:int32(L/2)]
  if Fy(m) < Fy(i)
    m = i;
  endif
endfor
```

```
disp('Violin4 -->');
disp('Fundamental frequency:');
disp(f(m));
disp('abs(DFT) at fundamental frequency:');
disp(abs(Fy(m)));
```

Q2)

```
# a = 4, piano4 fundamental frequency = 784 Hz
# ans = flute3, 793.5 Hz

# for flute1
[y,Fs] = audioread('flute1.wav');

# taking DFT
Fy = fft(y);

L = length(Fy);
N = length(y);

k = [0:L-1];

# getting frequencies
f = Fs/N .* k;

subplot(2,2,1);
plot(f,abs(Fy));
title('Flute1 - abs(DFT) VS Frequency');
xlabel('Frequency (Hz)');
```

```
ylabel('DFT(y(t))');

m = 1;
for i=[1:int16(L/2)]
  if Fy(m) < Fy(i)
    m = i;
  endif
endfor

disp('Flute1 -->');
disp('Fundamental frequency:');
disp(f(m));
disp('abs(DFT) at fundamental frequency:');
disp(abs(Fy(m)));


# for flute2

[y,Fs] = audioread('flute2.wav');

# taking DFT
Fy = fft(y);

L = length(Fy);
N = length(y);

k = [0:L-1];

# getting frequencies
```

```
f = Fs/N .* k;

subplot(2,2,2);
plot(f,abs(Fy));
title('Flute2 - abs(DFT) VS Frequency');
xlabel('Frequency (Hz)');
ylabel('DFT(y(t))');

m = 1;
for i=[1:int32(L/2)]
  if Fy(m) < Fy(i)
    m = i;
  endif
endfor

disp('Flute2 -->');
disp('Fundamental frequency:');
disp(f(m));
disp('abs(DFT) at fundamental frequency:');
disp(abs(Fy(m)));


# for flute3

[y,Fs] = audioread('flute3.wav');

# taking DFT
Fy = fft(y);
```

```
L = length(Fy);
N = length(y);

k = [0:L-1];

# getting frequencies
f = Fs/N .* k;

subplot(2,2,3);
plot(f,abs(Fy));
title('Flute3 - abs(DFT) VS Frequency');
xlabel('Frequency (Hz)');
ylabel('DFT(y(t))');

m = 1;
for i=[1:int32(L/2)]
  if Fy(m) < Fy(i)
    m = i;
  endif
endfor

disp('Flute3 -->');
disp('Fundamental frequency:');
disp(f(m));
disp('abs(DFT) at fundamental frequency:');
disp(abs(Fy(m)));

# for flute4
```

```
[y,Fs] = audioread('flute4.wav');

# taking DFT
Fy = fft(y);

L = length(Fy);
N = length(y);

k = [0:L-1];

# getting frequencies
f = Fs/N .* k;

subplot(2,2,4);
plot(f,abs(Fy));
title('Flute4 - abs(DFT) VS Frequency');
xlabel('Frequency (Hz)');
ylabel('DFT(y(t))');

m = 1;
for i=[1:int32(L/2)]
  if Fy(m) < Fy(i)
    m = i;
  endif
endfor

disp('Flute4 -->');
disp('Fundamental frequency:');
disp(f(m));
```

```
disp('abs(DFT) at fundamental frequency:');
disp(abs(Fy(m)));
```

Q3)

```
# importing humming sound
[y Fs] = audioread('humWav.wav');

# taking DFT of y
F = fft(y);

N = length(y);
L = length(F);
k = [0:L-1];

# defining freaquency
f = Fs/N .* k;

# plotting f VS abs(F)
plot(f,abs(F));
title('abs(DFT) VS frequency');
xlabel('Frequency (Hz)');
ylabel('DFT(y(t))');

# calculating fundamental frequency
m = 1;

for i=[1:int32(L/2)]
  if abs(F(i)) > abs(F(m))
```

```
    m = i;
  endif
endfor

disp('Humming Sound -->');
disp('Fundamental frequency:');
disp(f(m));
disp('abs(DFT) at fundamental frequency:');
disp(abs(F(m)));
```

Q4)

```
# importing audio file
[y Fs] = audioread('Opera.wav');

N = length(y)/10;

disp('Location of dominant peaks in Hz:');

# loop for consecutive N samples
for i=[1:10]
  ys = y(N*i-N+1:N*i);

  # calculating absolute values of DFT
  absF = abs(fft(ys));

  L = length(absF);
  k = [0:L-1];
  n = length(ys);
```

```
 # calculating frequencies
 f = Fs/n .* k;

 # plotting abs(DFT)
 subplot(5,2,i);
 plot(f,absF);
 s = [];
 title(i);
 xlabel('Frequency (Hz)');
 ylabel('abs(DFT(y(t)))');

 # finding dominant peak
 m = 1;
 for j=[1:int32(L/2)]
  if absF(m) < absF(j)
   m = j;
  endif
 endfor

 s = [char(i+'0'-1) ' ' 'Window'];
 disp(s);
 disp(f(m));

endfor
```

Q5)

```
# Uttering 'I'
[yi Fs] = audioread('III.wav');
```

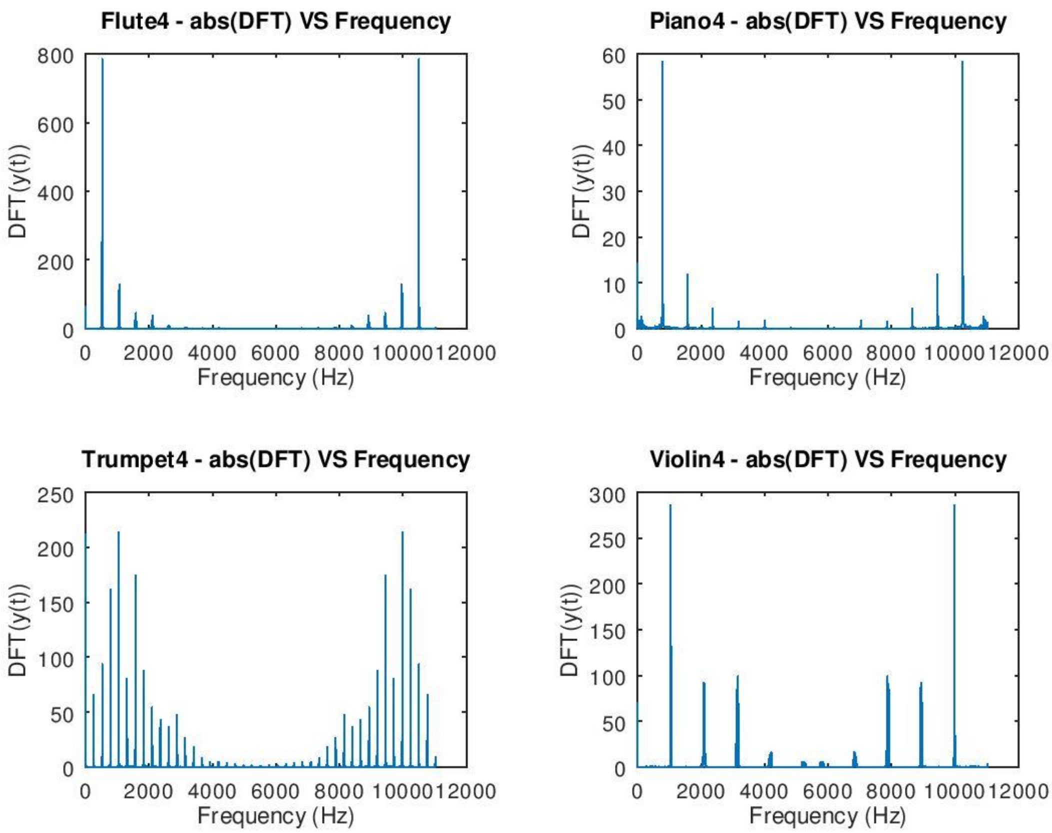
```
# finding DFT of yi
DFT = fft(yi);

N = length(yi);
L = length(DFT);
k = [0:L-1];

# finding frequencies
f = Fs/N .* k;

# plotting frequency spectrum
subplot(2,1,1);
plot(f,abs(DFT));
title('Uttering I');
xlabel('Frequency (Hz)');
ylabel('abs(DFT(y(t)))');

# finding fundamental frequency
m = 1;
for i=[1:int32(L/2)]
  if abs(DFT(i)) > abs(DFT(m))
    m = i;
  endif;
endfor

disp('Fundamental Frequency of I (Hz):');
disp(f(m));
```

```
# Uttering ‘O’
[yo Fs] = audioread('OOO.wav');

# finding DFT of yo
DFT = fft(yo);

N = length(yo);
L = length(DFT);
k = [0:L-1];

# finding frequencies
f = Fs/N .* k;

# plotting frequency spectrum
subplot(2,1,2);
plot(f,abs(DFT));
title('Uttering O');
xlabel('Frequency (Hz)');
ylabel('abs(DFT(y(t)))');

# finding fundamental frequency
m = 1;
for i=[1:int32(L/2)]
  if abs(DFT(i)) > abs(DFT(m))
    m = i;
  endif;
endfor
```

```
disp('Fundamental Frequency of O (Hz):');

disp(f(m));
```

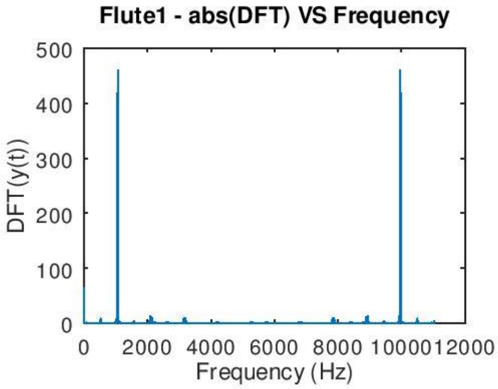
Graphs and Observations:

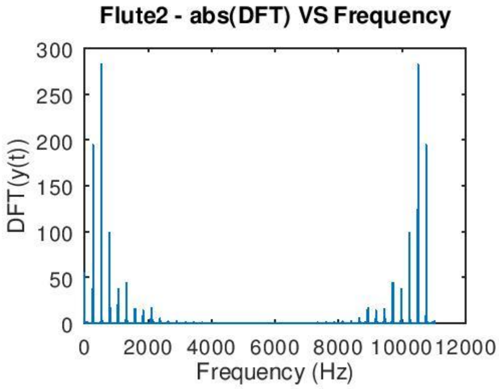
Q1)

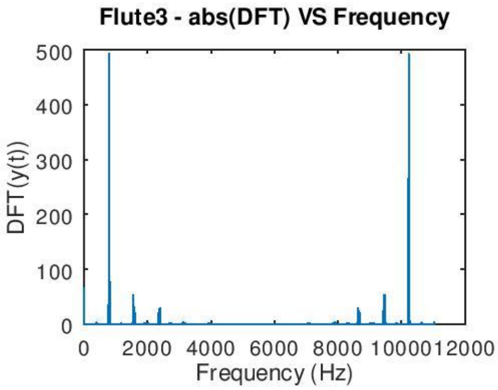


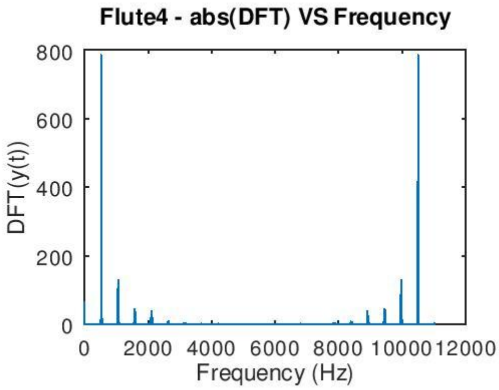
Instrument	Fundamental Frequency (Hz)	Absolute value of DFT
Flute4	524.4	784.42
Piano4	784	58.258
Trumpet4	1046.6	213.46
Violin4	1039.5	286.04

Q2)







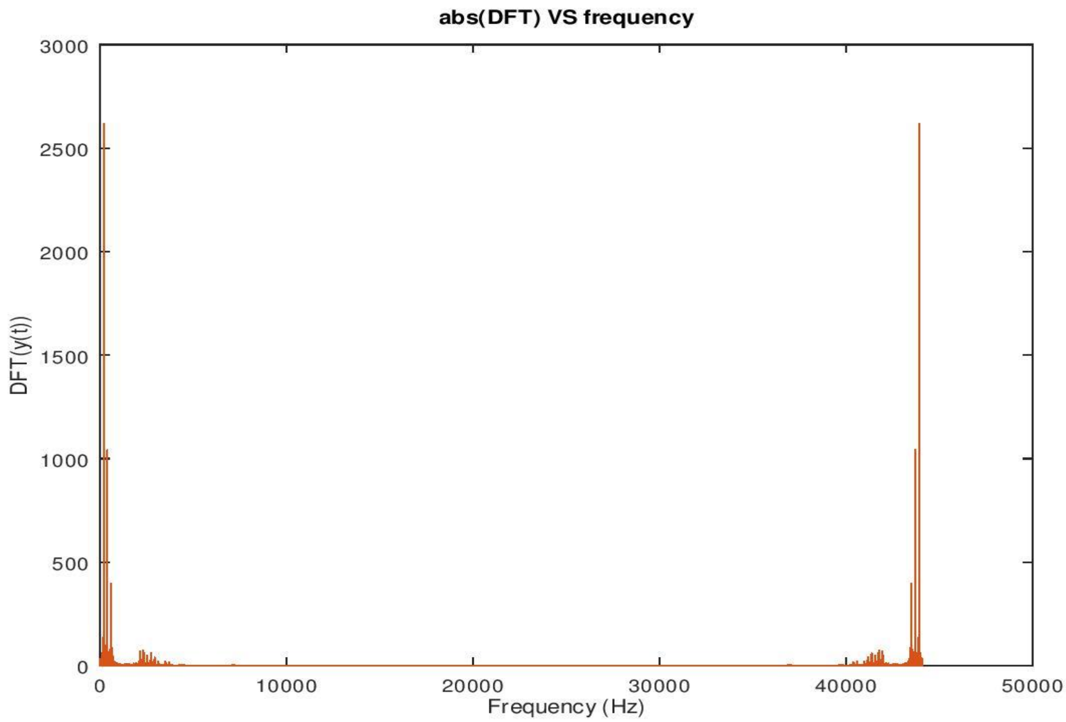


Instruments	Fundamental Frequency (Hz)
Flute1	1063.2
Flute2	524.33
Flute3	793.5
Flute4	524.4

It can be seen that the flute3 has closest relation to piano4 as their fundamental frequencies are 793.5 Hz and 784 Hz respectively.

Q3)

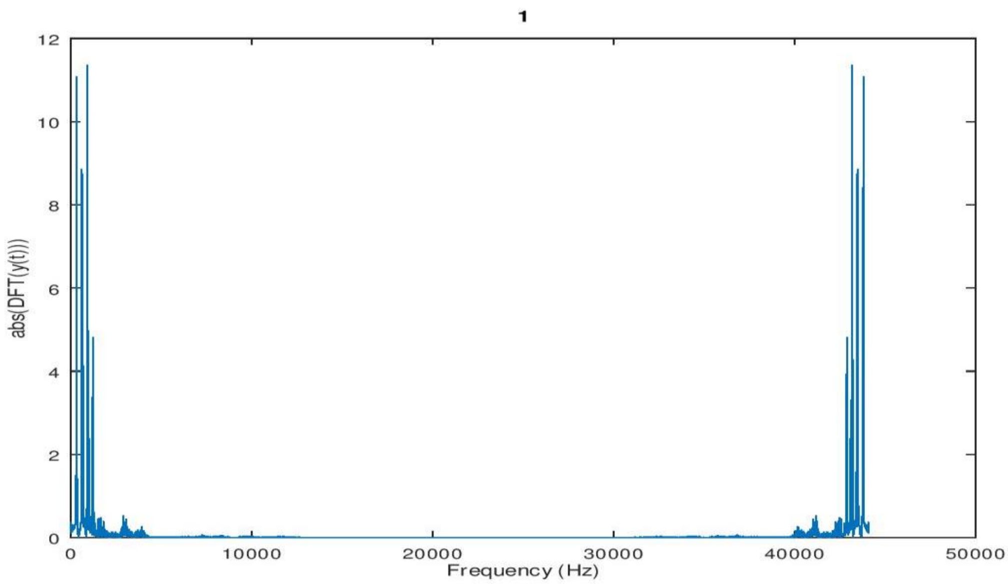
The fundamental frequency of the humming sound was found to be 194.83 Hz and the absolute value of its DFT was found to be 2619.0

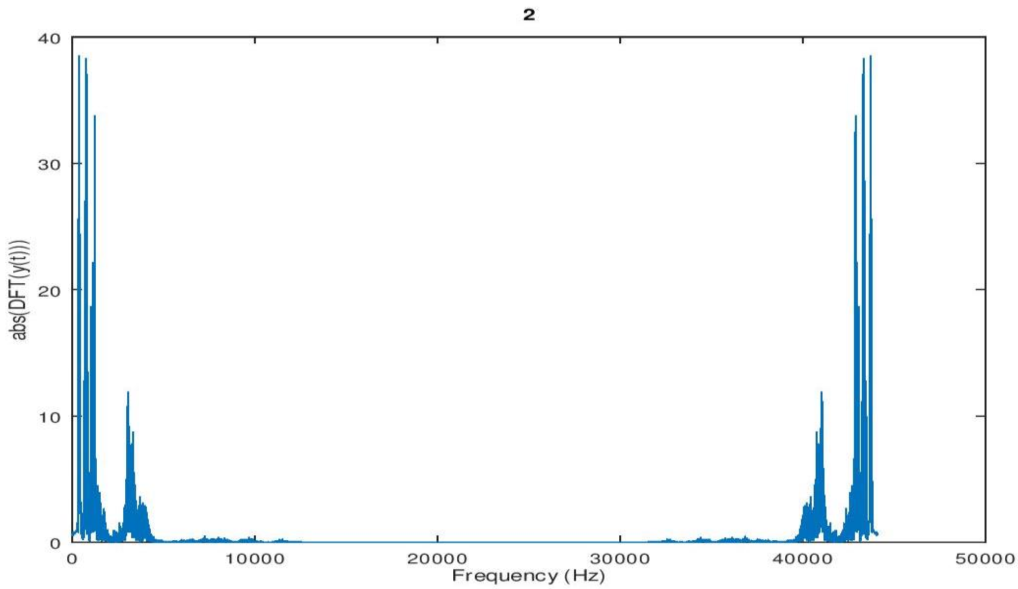


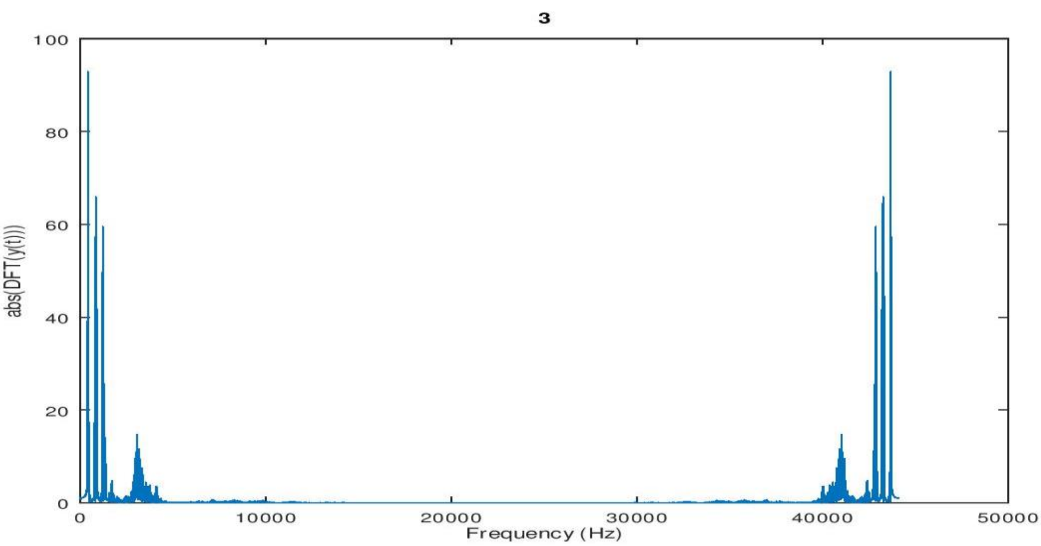
Q4)

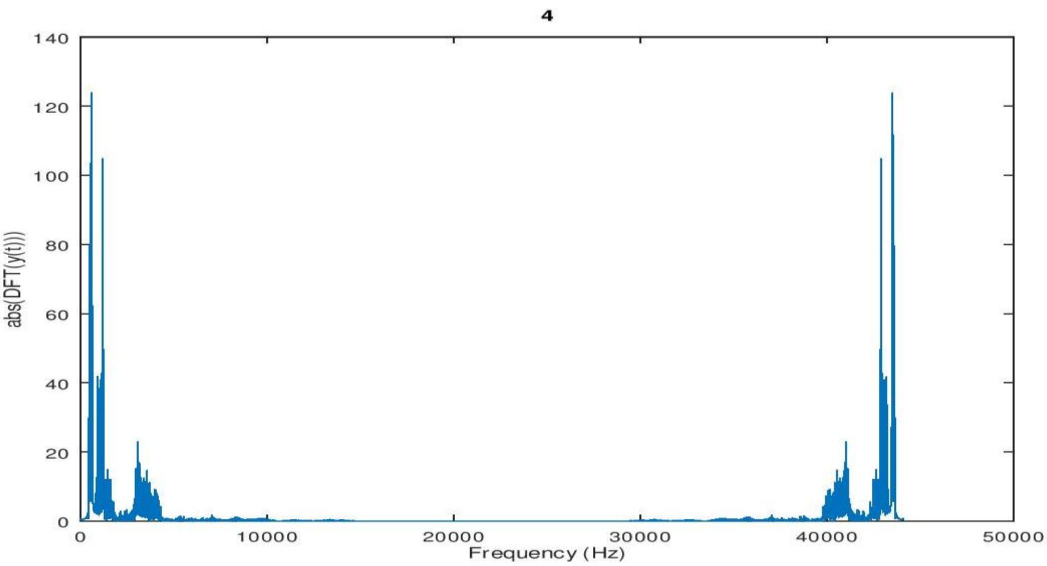
The temporal variation was captured by taking DFTs at certain continuous intervals consisting of Total/10 samples. It is seen that the fundamental frequency in every time interval is different. So the dominant peaks are at different frequencies.

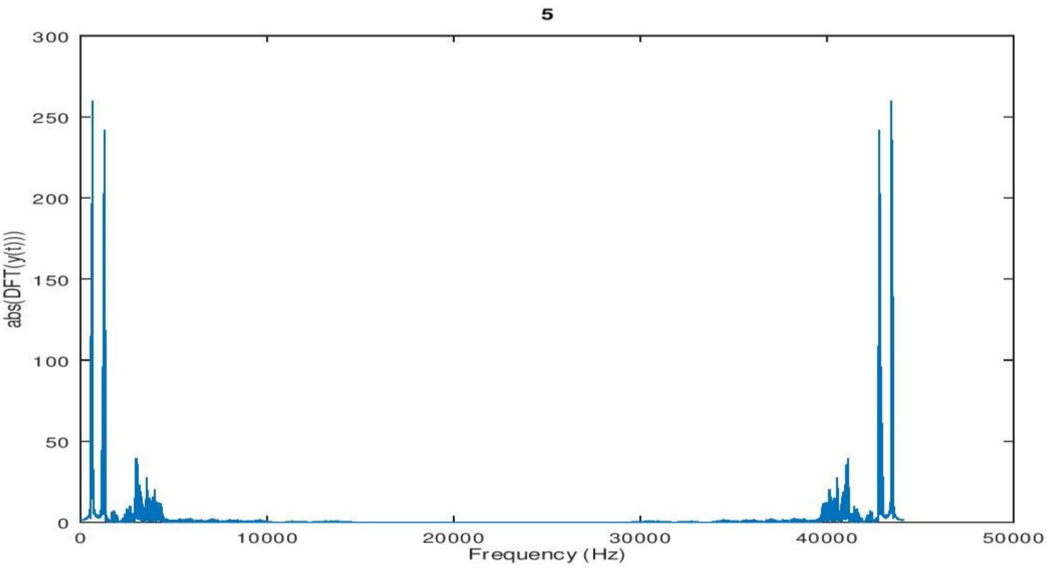
Time Window/Interval	Fundamental Frequency (Hz)
0	914
1	380
2	420
3	580
4	634
5	616
6	624
7	1288
8	482
9	404

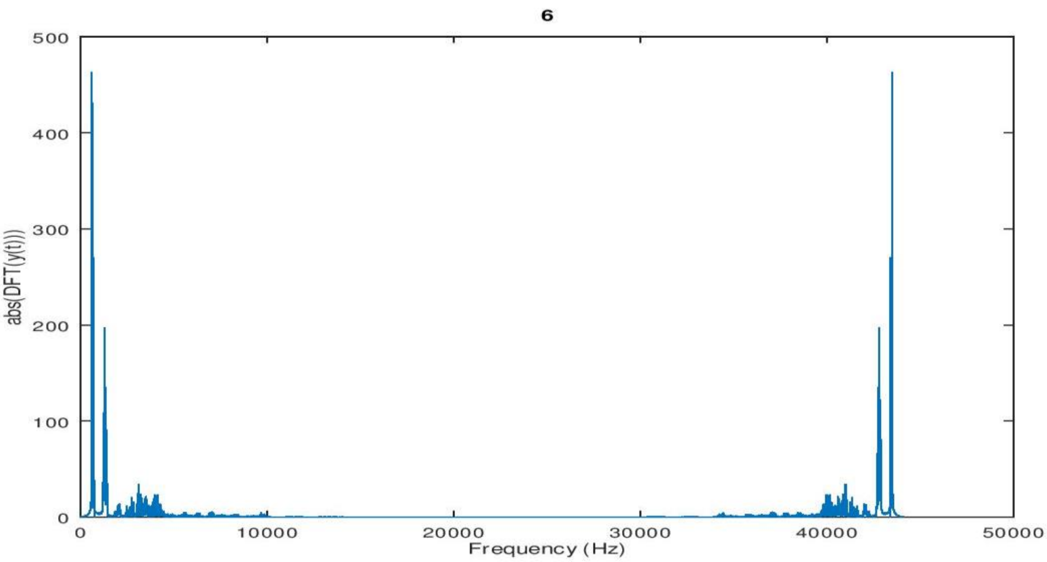

1
abs(DFT(y(t)))
Frequency (Hz)
0
2
4
6
8
10
12
0
10000
20000
30000
40000
50000

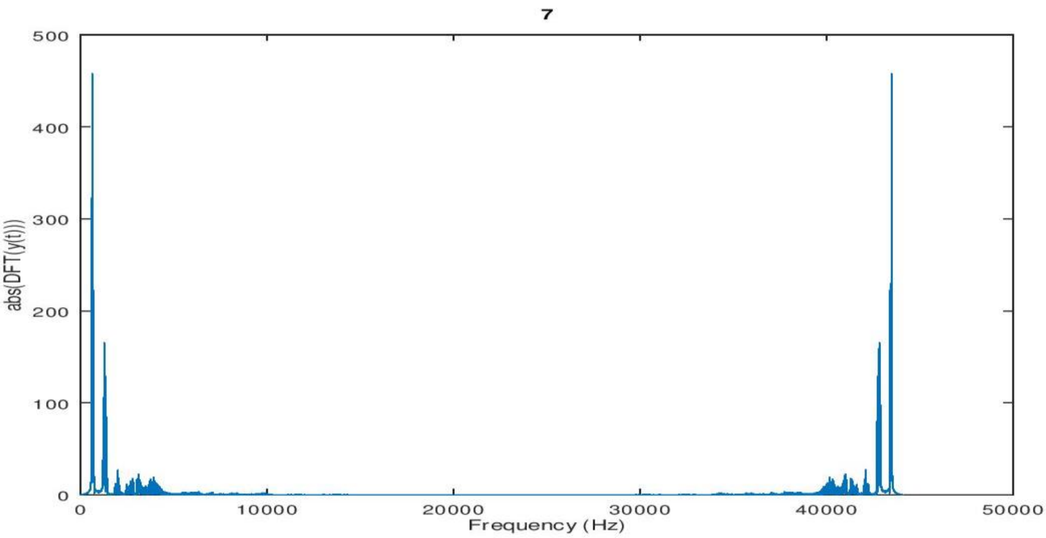

2
abs(DFT(y(t)))
Frequency (Hz)
0
10
20
30
40
0
10000
20000
30000
40000
50000

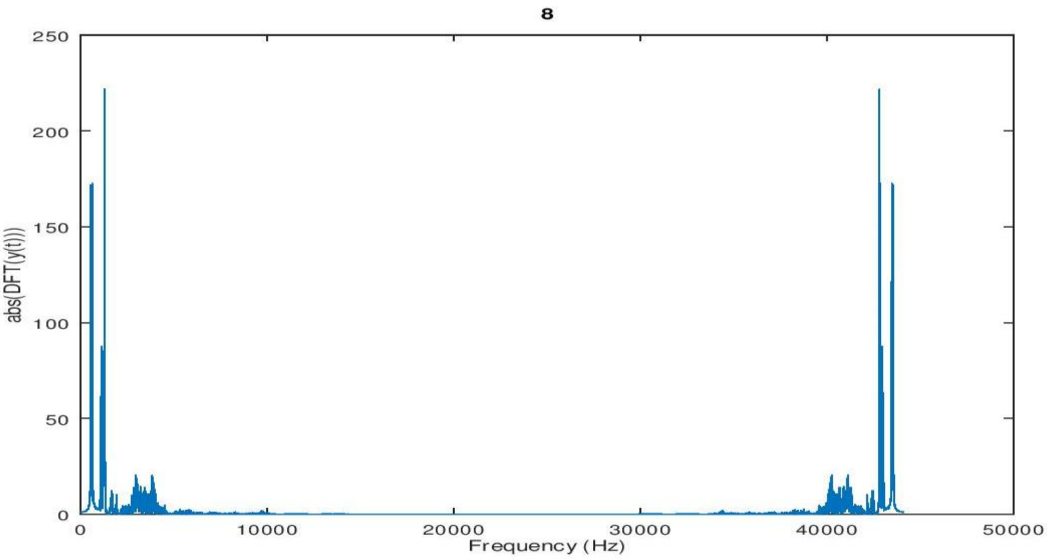

3
abs(DFT(y(t)))
Frequency (Hz)
0
20
40
60
80
100
0
10000
20000
30000
40000
50000

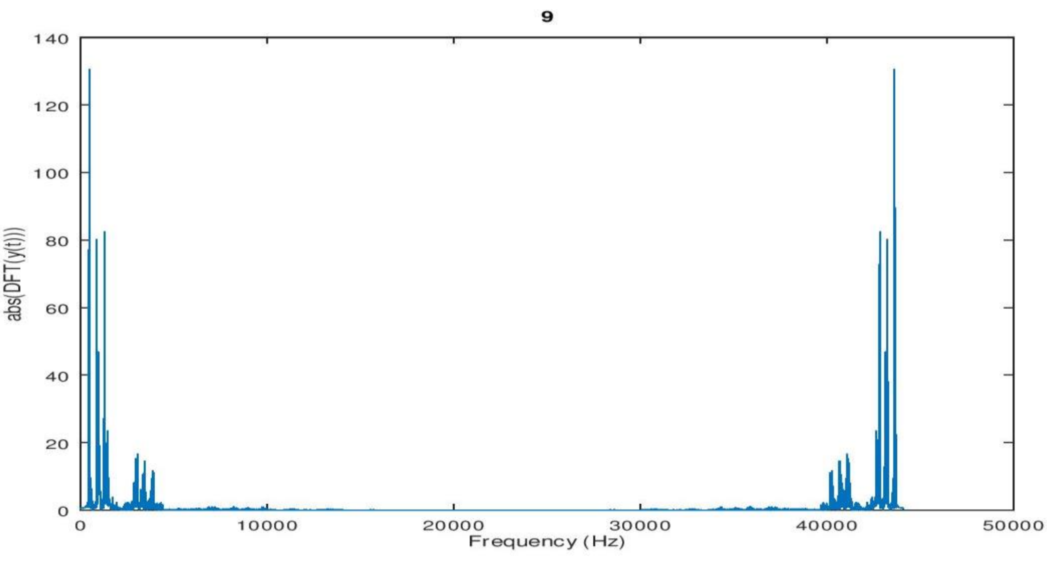

4
140
120
100
80
60
40
20
0
abs(DFT(y(t)))
0
10000
20000
30000
40000
50000
Frequency (Hz)

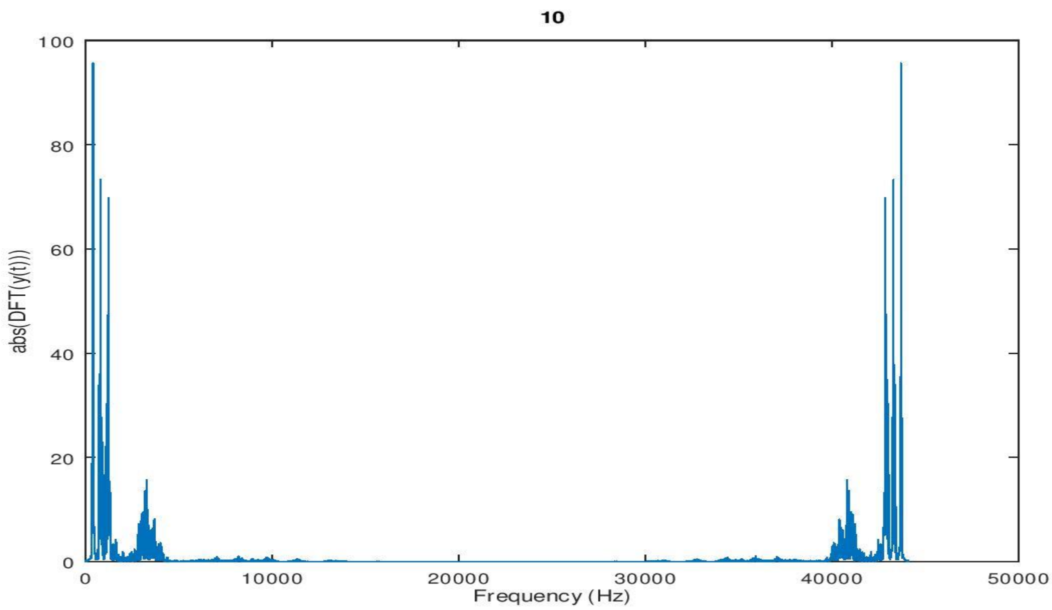

5
300
250
200
150
100
50
0
abs(DFT(y(t)))
0
10000
20000
30000
40000
50000
Frequency (Hz)


6
500
400
300
200
100
0
abs(DFT(y(t)))
0
10000
20000
30000
40000
50000
Frequency (Hz)

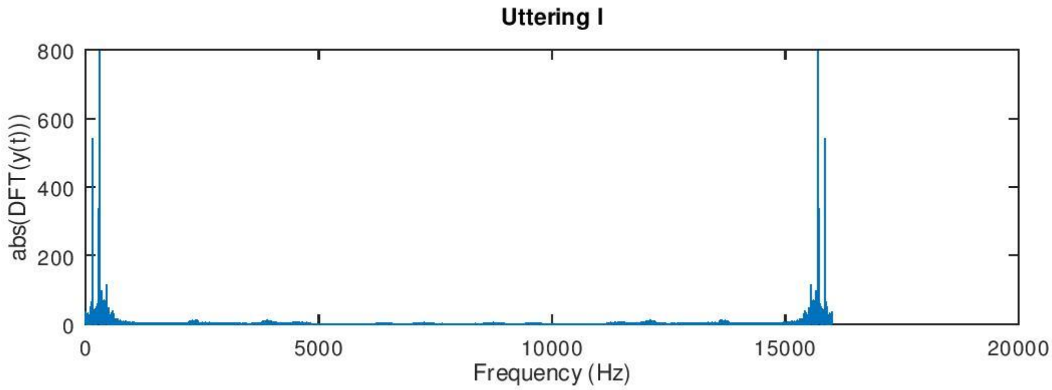

7
abs(DFT(y(t)))
Frequency (Hz)
0
100
200
300
400
500
10000
20000
30000
40000
50000

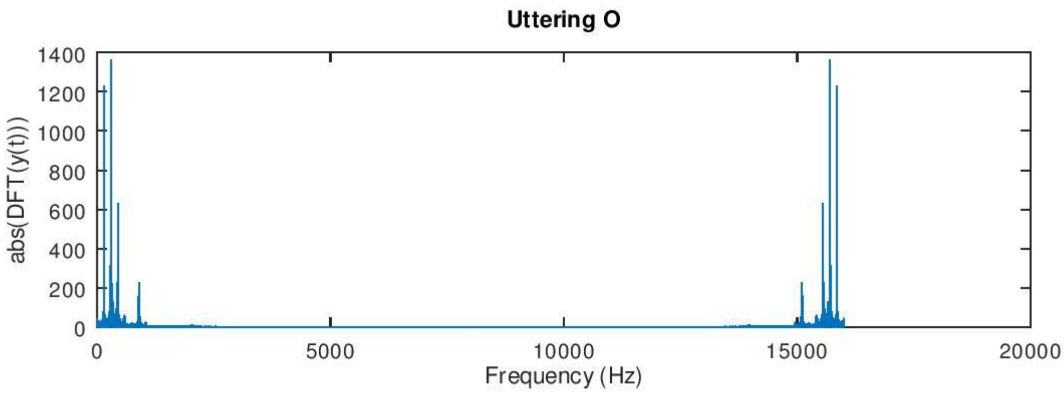

8
abs(DFT(y(t)))
Frequency (Hz)
0
50
100
150
200
250
10000
20000
30000
40000
50000


9
abs(DFT(y(t)))
Frequency (Hz)
0
20
40
60
80
100
120
140
10000
20000
30000
40000
50000



Q5)





It is seen that uttering ‘I’ and uttering ‘O’ have similar fundamental frequencies of 297.55 Hz and 302.05 Hz. So the dominant peaks are slightly apart.

Conclusions:

1. The fundamental frequencies of different instruments were found out using FFT.
2. The closest flute audio was found to piano4.
3. The fundamental frequency of the humming sound was found out.
4. The temporal variations of the opera was captured and plotted.
5. The uttering of two vowels was done and their fundamental frequency was captured.