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Harmonium and Piano frequencies

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Abstract - *Swaras are distinct musical notes which are produced when a key of harmonium/piano are pressed. Ragas are made of different swaras. These swaras have different frequencies. So, in this paper we will study the math behind these sounds produced by harmonium and piano using the concept of octaves, harmonics and vibrations. Using Bosch iNVH app, segmentation of the audio signal by different notes produced by piano/harmonium is conducted. Then FFT analysis will be done on A, B, D, E and G note as an example also comparison of A3, E3 and B3 are compared via MATLAB software. Then answer to why some combinations of swaras are melodious and why some are irritating can be found and also how a human ear reacts when some characteristics of sound is changed. Using different tones, keys, swaras and ragas, the mathematics of the harmonics and vibrations can be understood using the concept of octaves. There will also be FFT analysis on the tunes to find some major notes which are major constituents of that tune. FFT analysis on the MATLAB of the tune will also be accompanied by the spectral analysis of that particular tune. We will then be able to compare for different instruments how the tune turns out to be.*

***Key Words*: FFT analysis, notes, swaras, MATLAB, octaves, spectral analysis, harmonics, instruments**

1.INTRODUCTION

Music is made out of melodic sounds (tones) which are hints of changing pitch (frequencies). A pure tone is a consistent intermittent sound with a sinusoidal waveform. The recurrence (pitch) is the primary trademark property of a pure tone. A melodic tone is unique in relation to a pure tone in that it tends to be portrayed by its timbre, duration, intensity, or loudness. The supreme duration of any note will rely upon the general duration of the note and the tempo of the piece. Notwithstanding these qualities of music sounds, there are specific melodic terms that depict the exhibition procedures, which influence the perception of music. In this manner, in physical terms, any piece of music is a temporal arrangement of hints of specific waveforms, frequencies, amplitudes, and durations along with pauses between them. In Indian classical music, swaras are melodic notes which are created by pressing any key of the harmonium. Ragas are melodic blends of swaras which catch the state of mind and feelings of the presentation. Piano is an instrument analogous to harmonium. By using certain applications on mobile devices, the frequency of each and every note in western as well as Indian classical is determined and a chart is prepared. Then, an unknown raga will be performed by an expert and using the same application, I will be able to find out what notes were actually there in that raga. And then using some mathematics we will find out the relation of harmonics, wavelength of the note, etc. Pythagoras saw that multiplying, quadrupling, or in any event, splitting a recurrence doesn't essentially modify the subsequent sound. The pitch is extraordinary; however, the perception is that the sounds are the equivalent in a crucial regard. These twofold or half frequencies are called octaves. Albeit an octave is an interval which could have any absolute frequencies as endpoints, the range of a melodic sound range has been separated in particular way into a lot of nearby octaves. These intervals are referred to by number. The center point of the piano keyboard has octaves number 3 and 4, and they are the normal range of most music. An overtone is any recurrence, which is more noteworthy than the fundamental recurrence of a sound. The marvel of the dissonance by the nearness of beats between higher sounds. Hence, just inflection or pure sound tuning framework has been made. In this framework, the frequencies of sounds identified with one another by the ratios of little entire numbers (Octave — 1:2, Fifth — 2:3, Quart — 3:4, Major Third — 4:5, Minor Third — 5:6, Major Tone — 8:9, Minor Tone — 9:10, Semitone — 15:16). The outcome is a diatonic scale, which is completely amicable, however creates wolf intervals. Pieces, which utilize this scale, can't be effectively transposed to an alternate key. Accordingly, a twelve-tone equivalent temperament has been made in which each pair of adjacent pitches of all the 12 sounds is isolated by a similar interval with the ratio of frequencies, which is equivalent to the twelfth root of two. For old style and Western music, this framework that partitions the octave into 12 sections, which are all equivalent on a logarithmic scale.

Pressing a piano's key makes a mallet strike a lot of rigid strings; the sledge at that point falls from the strings so as not to dampen their vibration. The vibration of the strings delivers the sound that we hear and perceive as the strike of a piano's critical. The quality of the sound we hear is dictated by the amplitude and frequency of the string's vibration, which thus are identified with the length, measurement, strain and thickness of the string. Most pianos have 88 keys with the furthest left key delivering the least frequency sound. The keys on a piano are organized in a repetitive manner of 12 keys (7 white and 5 dark) as demonstrated as follows.

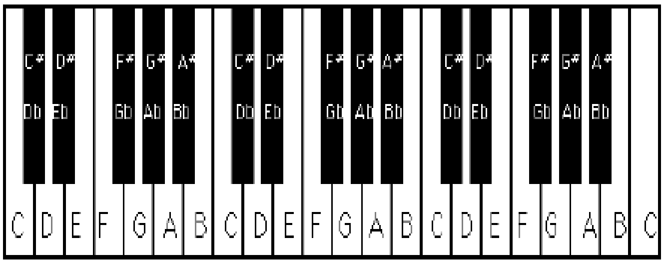

Fig -1: The part of piano (image from www.Piano-Keyboard-Guide.com)

2. LITERATURE REVIEW

A sound can be described by the accompanying three amounts: (i) Pitch. (ii) Quality. (iii) Loudness. Pitch is the frequency of a sound as seen by human ear. A high frequency offers ascend to a high pitch note and a low frequency delivers a low pitch note. An unadulterated tone is the sound of just a single frequency, such as that given by a tuning fork or electronic signal generator. The essential note has the best adequacy what's more, is heard overwhelmingly in light of the fact that it has a bigger force. Different frequencies, for example, 2fo, 3fo, 4fo... are called suggestions or music and they decide the quality of the sound. Loudness is a physiological sensation. It relies principally upon sound weight yet additionally on the range of the music and the physical duration. Human can hear signal frequency extending from 20-20 kHz. Various pianos are having various extents. Each tone of piano is having one specific fundamental frequency and spoke to by a note like C, D, ...and so on. The later C is 12 half steps away the past one and having twofold the fundamental frequency. Henceforth this segment (from one C prompt next C) is called one octave. Various octaves are separated by C1, C2, and so on. The Fast Fourier Transform doesn't allude to some other kind of Fourier transform. It alludes to an effective calculation for computing the DFT. The time taken to assess a DFT on a PC depends primarily chiefly on the quantity of duplications included. DFT needs N2 duplications. FFT just needs Nlog2(N). The focal knowledge which prompts this calculation is the acknowledgment that a discrete Fourier transform of an arrangement of N focuses can be written regarding two discrete Fourier transforms of length N/2. Along these lines if N is an intensity of two, it is conceivable to recursively apply this deterioration until we are left with discrete Fourier transforms of single focuses. Fourier series can decompose any periodic signal or function into the sum of simple goniometric functions, namely digital signal into the frequency-domain signal. This methodology is extremely helpful for deciding modular boundaries of vibrating frameworks. On the off chance that the vibrating framework creates clamor during its vibration, it is conceivable to record commotion to the digital wave document and utilize the information for additional preparing. This paper portrays a portion of the fundamentals of FFT and examines a model how eigenfrequencies of loud vibrating framework can be recorded to a digital sound document. Fourier examination was performed utilizing programming MATLAB.

3. DIGITAL SIGNAL PROCESSING

3.1Sampling

All the notes of keyboard as well as of the harmonium were played and recorded by computer for the FFT analysis. Then, they were used as input in the MATLAB. Along with the notes, tunes were also recorded. 'Twinkle-twinkle little star' and 'Clap your hands' tune is recorded on piano and 'Yamana' raga was played on harmonium.

3.2. Experimentation

Using the applications on the mobile, the frequencies of all the notes were determined. Then using the below formula, wavelength was found out.

$$\lambda = \frac{c}{f}$$

Where c is the speed of sound in air in m/s and f is the frequency of the particular note in Hz.

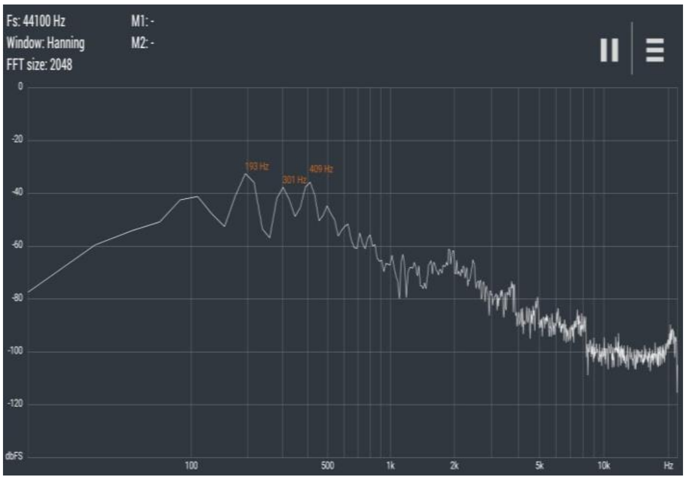

Fig -2: The application that was used to determine the frequency of notes.

Then using the MATLAB software, by writing some codes, FFT analysis of the notes and the tunes were performed. When FFT was done, we could also determine the notes in the present in the tune. Besides this, spectral analysis was also done on tunes.

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3.3. Result

Notes on Piano	Frequency (Hz)	Wavelength (m)	Time Period
C2	65.9	5.20	15.17
C#2	69.9	4.91	14.31
D2	73.9	4.64	13.53
D#2	78.1	4.39	12.80
E2	82.7	4.15	12.09
F2	87.9	3.90	11.38
F#2	92.7	3.70	10.79
G2	97.5	3.52	10.26
G#2	104.4	3.29	9.58
A2	109.9	3.12	9.10
A#2	117.3	2.92	8.53
B2	124.4	2.76	8.04
C3	131.4	2.61	7.61
C#3	139.4	2.46	7.17
D3	147.5	2.33	6.78
D#3	155.9	2.20	6.41
E3	165	2.08	6.06
F3	173.3	1.98	5.77
F#3	184.1	1.86	5.43
G3	195.6	1.75	5.11
G#3	207.8	1.65	4.81
A3	219.1	1.57	4.56
A#3	233.3	1.47	4.29
B3	245.9	1.39	4.07
C4	260.5	1.32	3.84
C#4	277.5	1.24	3.60
D4	292.3	1.17	3.42
D#4	311.2	1.10	3.21
E4	331.1	1.04	3.02
F4	347.5	0.99	2.88
F#4	370.3	0.93	2.70
G4	390.2	0.88	2.56
G#4	415.1	0.83	2.41
A4	439.9	0.78	2.27
A#4	467.2	0.73	2.14
B4	495.1	0.69	2.02
C5	522.5	0.66	1.91
C#5	553.4	0.62	1.81
D5	589.7	0.58	1.70
D#5	623.8	0.55	1.60
E5	660.2	0.52	1.51
F5	699.6	0.49	1.43
F#5	741.6	0.46	1.35
G5	785.7	0.44	1.27
G#5	832.6	0.41	1.20
A5	881.1	0.39	1.13
A#5	932.5	0.37	1.07
B5	991.6	0.35	1.01
C6	1046.3	0.33	0.96
C#6	1112.6	0.31	0.90
D6	1178.8	0.29	0.85
D#6	1249.1	0.27	0.80
E6	1323.4	0.26	0.76
F6	1402	0.24	0.71
F#6	1484.4	0.23	0.67
G6	1573.4	0.22	0.64
G#6	1666.1	0.21	0.60
A6	1765.1	0.19	0.57
A#6	1870.7	0.18	0.53
B6	1981.2	0.17	0.50
C7	2100.1	0.16	0.48

Fig -3: The list of notes of piano and their wavelength, frequency and time period

	Swara on Harmonium	Frequency (Hz)	Equivalent note on Piano	Wavelength (m)	Time Period (ms)
Lower	sa	139.1	C#3	2.47	7.19
	re (komal)	147.3	D3	2.33	6.79
	re	155.7	D#3	2.20	6.42
	ga (komal)	164.8	E3	2.08	6.07
	ga	174.5	F3	1.97	5.73
	ma	185.9	F#3	1.85	5.38
	ma (tivra)	195.8	G3	1.75	5.11
	pa	207.7	G#3	1.65	4.81
	dha (komal)	220.8	A3	1.55	4.53
	dha	233.4	A#3	1.47	4.28
	ni (komal)	246.9	B3	1.39	4.05
	ni	261.1	C4	1.31	3.83
Middle	sa	277.1	C#4	1.24	3.61
	re (komal)	292.8	D4	1.17	3.42
	re	311.5	D#4	1.10	3.21
	ga (komal)	330.9	E4	1.04	3.02
	ga	350.1	F4	0.98	2.86
	ma	370.4	F#4	0.93	2.70
	ma (tivra)	391.2	G4	0.88	2.56
	pa	415.1	G#4	0.83	2.41
	dha (komal)	440.1	A4	0.78	2.27
	dha	465	A#4	0.74	2.15
	ni (komal)	494.8	B4	0.69	2.02
	ni	522.9	C5	0.66	1.91
High	sa	553.8	C#5	0.62	1.81
	re (komal)	586.1	D5	0.59	1.71
	re	622	D#5	0.55	1.61
	ga (komal)	659.4	E5	0.52	1.52
	ga	698.5	F5	0.49	1.43
	ma	739.3	F#5	0.46	1.35
	ma (tivra)	784.2	G5	0.44	1.28
	pa	831.1	G#5	0.41	1.20
	dha (komal)	878.8	A5	0.39	1.14
	dha	932.2	A#5	0.37	1.07
	ni (komal)	987.6	B5	0.35	1.01
	ni	1045.7	C6	0.33	0.96

Fig -4: The notes of harmonium; their frequency, wavelength and time period

We see from the plot in figure 5 that the amplitude of the signal decays with time. In this case, I have used an exponential damping with tau=0.43. Note that while the assumption of exponential damping is not a perfect fit. Zooming the plot between 0.6 and 0.7 seconds. From the zoomed-in plot in figure 6, we observe that the signal is periodic in nature.

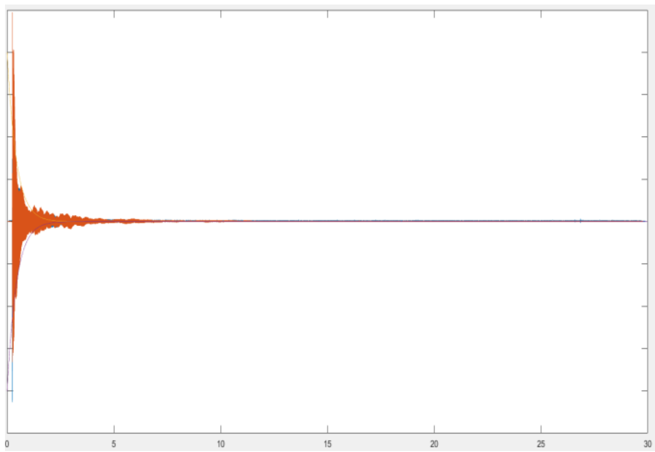

Fig -5: A snapshot from the MATLAB after A4 note is fed into the code

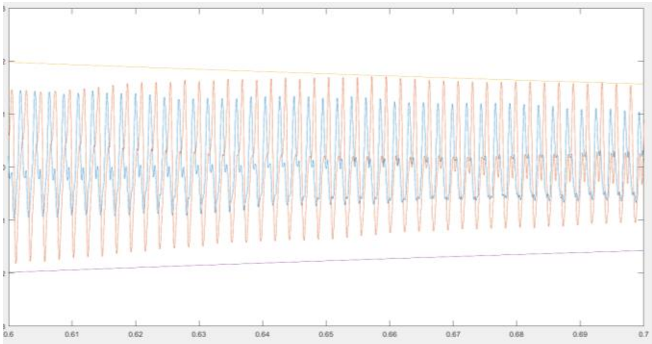

Fig -6: A440 is harmonic in nature

Looking at the plot in figure 7 in more detail, we see that the key frequency components are at 440Hz, 880Hz, 1323Hz, 1765Hz. Using the list of frequencies, we determine that the musical notes corresponding to the observed frequency components are A4, A5, E6 and A6.

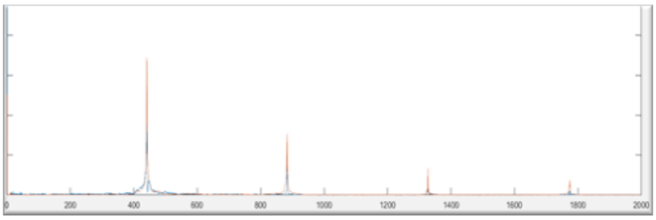

Fig -7: The magnitude on y-axis and frequency on x-axis

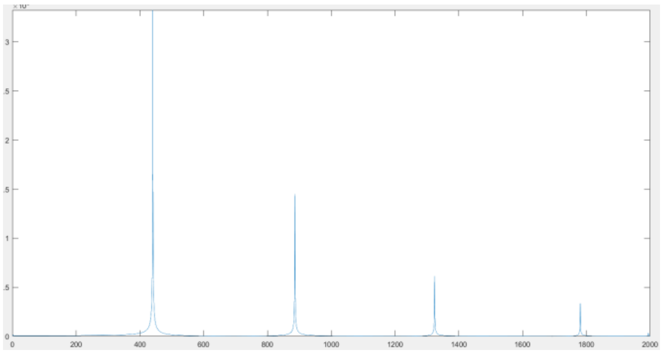

Fig -8: Isolated peaks with increase in magnitude

On selecting the peaks seen in figure 7, we get all the selected peaks are isolated with their magnified magnitude shown in figure 8. Observe that the note pairs {A4 A5 A6} by a factor of two, and that the amplitude of A4>A5>E6>A6. This implies that A4 is a fundamental note and A5, E6 and A6 are its harmonics.

In the figures 9, 10, 11, 12, 13, the plot of Amplitude vs Time is zoomed between a particular time interval of notes A, B, D, E and G respectively. We are able to observe that the particular thing varying between them is the waveform. Also, the waveforms of some particular notes are present in each other which are each other's overtone. For example, A-note and E-note are overtones of each other, and their waveform are present in each other. All of the notes' frequency also differ.

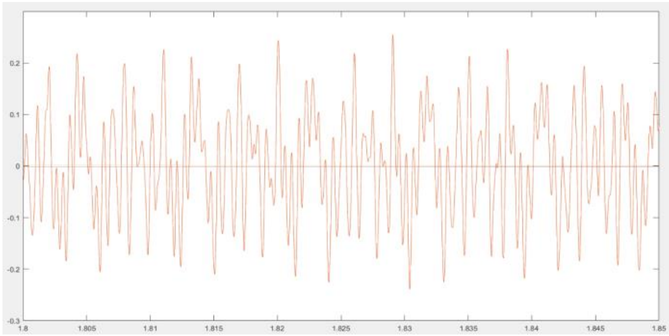

Fig -9: A-note, when zoomed

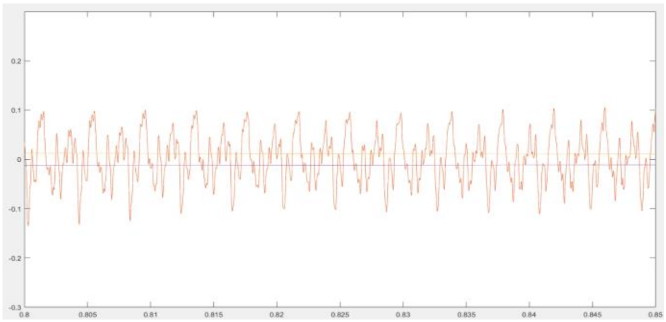

Fig -1: B-Note, when zoomed

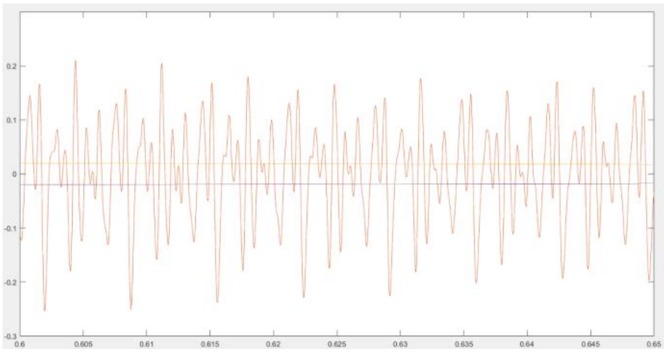

Fig -2: D-Note, when zoomed

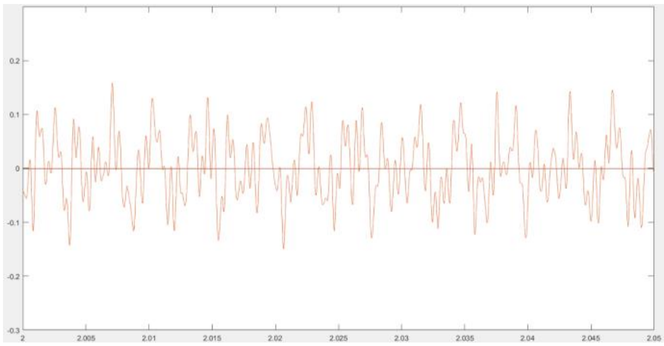

Fig -3: E-note, when zoomed

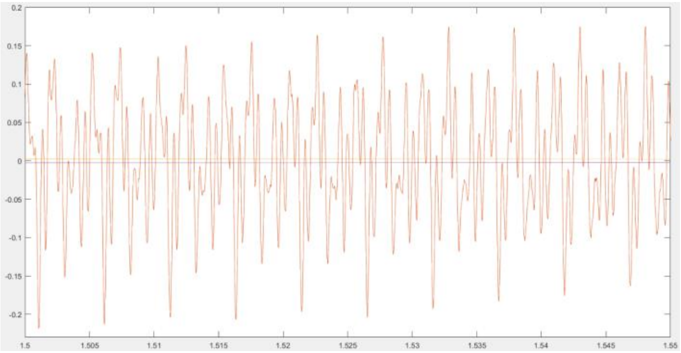

Fig -4: G-Note, when zoomed

Next FFT was performed on A3, E3 and B3 notes to know how these differ. In figure 14, we can observe that the peak frequencies are 220Hz, 440Hz, 660Hz and 880 Hz which corresponds to A3, A4, E5 and A5 respectively. Amongst this the order of the amplitudes is A3>A4>E5>A5. This implies that A3 is the fundamental frequencies and others are its overtones in the whole number ratio.

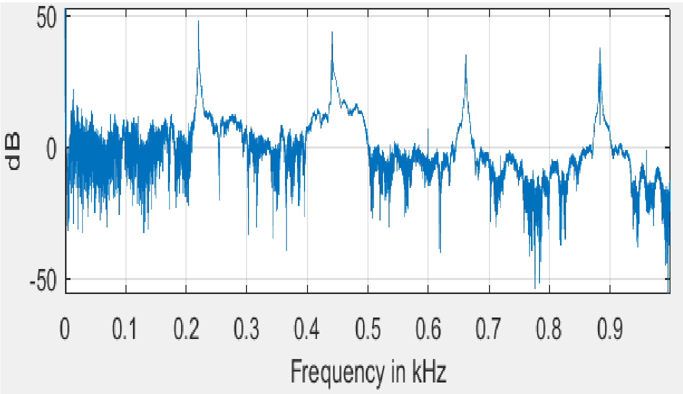

Fig -14: FFT on A3 note

In figure 15 we can observe that the peak frequencies are 165Hz, 330Hz, 495.1Hz, 660Hz, 830Hz and 990Hz which corresponds to E3, E4, B4, A5, G#5 and B5 respectively. Amongst this the order of the amplitudes is E3>E4>B4>A5>G#5>B5. This implies that E3 is the fundamental frequencies and others are its overtones in the whole number ratio.

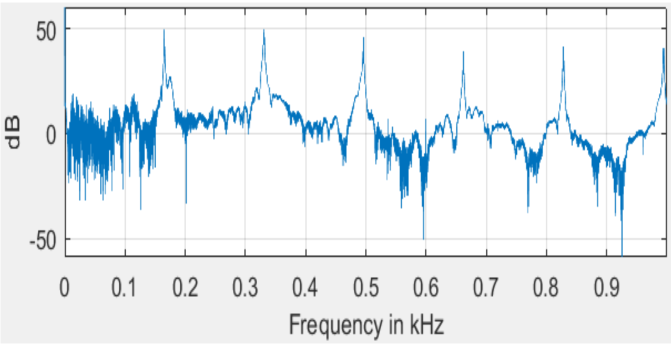

Fig -15: FFT on E3 note

In figure 16 plot we can observe that the peak frequencies are 245Hz, 495Hz, 740Hz and 990Hz which corresponds to B3, B4, F#5 and B5 respectively. Amongst this the order of the amplitudes is B3>B4>F#5>B5. This implies that B3 is the fundamental frequencies and others are its overtones in the whole number ratio.

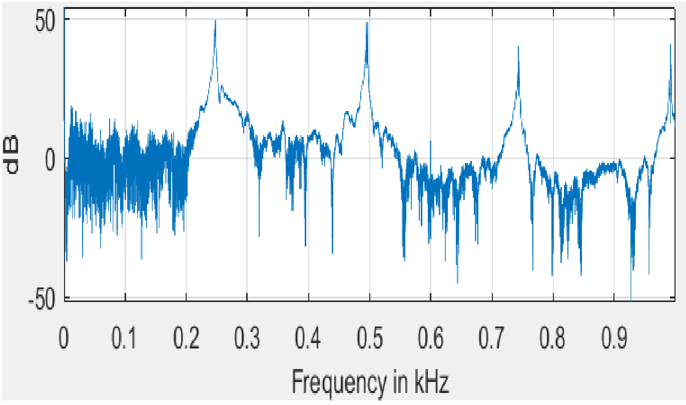

Fig -16: FFT on B3 note

In the figure 17 which is shown below, where Y-axis represents Frequency in Hertz x 10^4 and X-axis represents Time in seconds. As we can see that at 400Hz the corresponding energy is maximum. Then, the energy is short lived and in decreasing order when the frequencies increases. Then, in other regions the energy is 0.

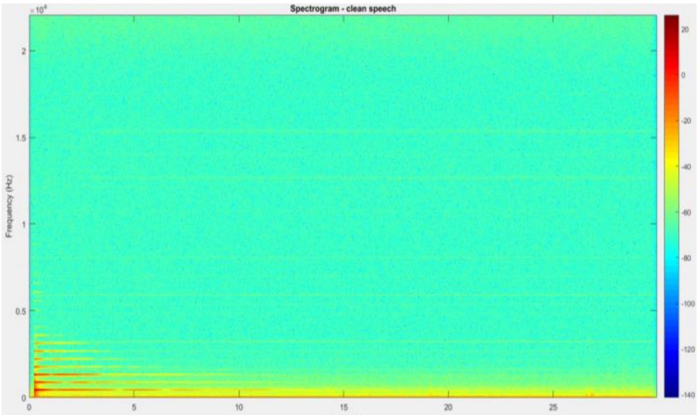

Fig -17: Spectrogram on A4 note

The tune of traditional raga 'Yamana raga' was played on the keyboard. Then, the tune was recorded. FFT analysis was carried out on that recording. At first, figure 18 shows Magnitude on Y-axis and on X-axis, Time is represented in seconds. In the Figure 19, the Fast Fourier Transform (FFT) of the raga, where in Y axis the loudness in dB is shown and the Frequency in kHz is shown. We can infer that the recording had a loudness of around 72dB.

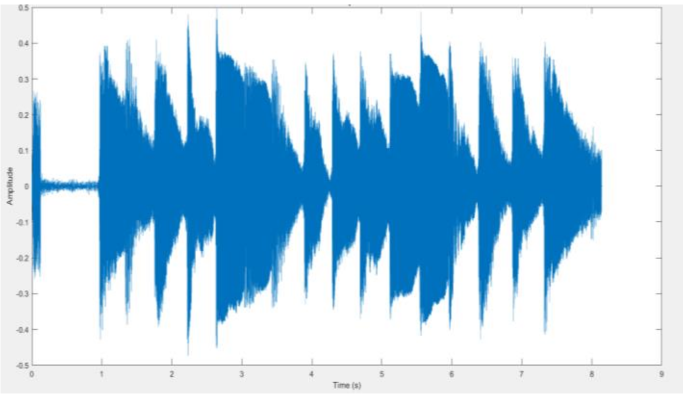

Fig -18: Amplitude vs Time for Yamana raga

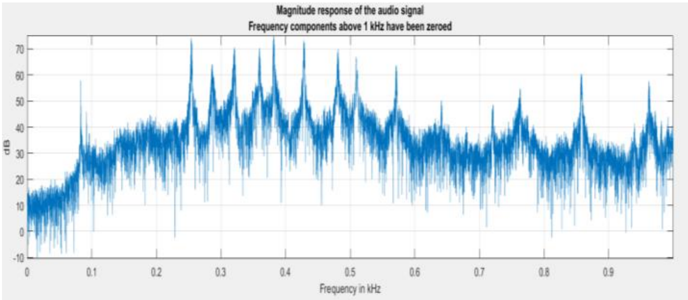

Fig -19: FFT of Yamana raga

In the figure 20, shown above, spectrogram of the 'Yamana raga' was conducted on the MATLAB software itself. Y-axis represents Frequency in Hertz x 10^4 and X-axis represents Time in seconds. We can observe that maximum overtone that can be included in the tune is around 10,000 Hz. Then, beyond 10,000 Hz, the energy is 0. Furthermore, at around lower frequencies till 2500 Hz the energies are maximum and beyond that the energy starts to fade.

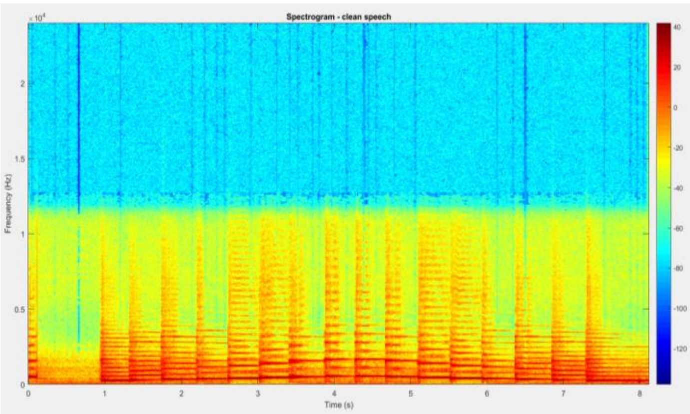

Fig -20: Spectrogram of Yamana raga

In the figure 21, we see some peaks and troughs throughout the graph. Selecting the peaks, helps us isolate those. These peaks are shown below in figure 22. The corresponding frequencies of these peaks are then shown as the result in MATLAB, depicted in figure 23. These frequencies when checked into the tables in figure 3 and 4, gives the keys that were pressed to make that particular tune.

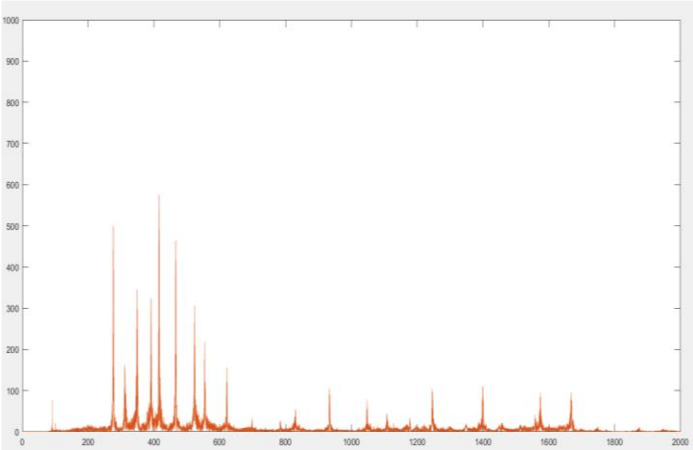

Fig -21: FFT (Magnitude vs Frequency) of Yamana raga

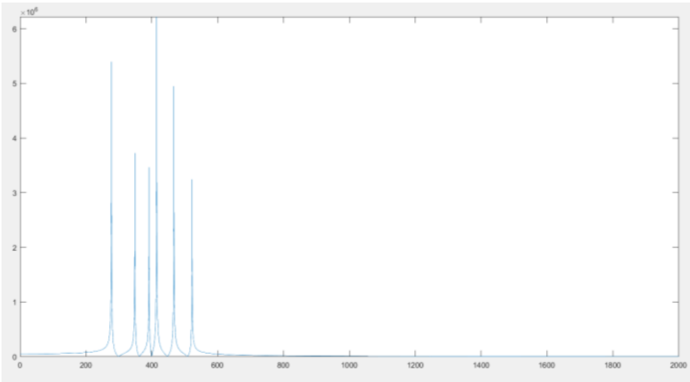

Fig -22: Isolated peaks for Yamana raga

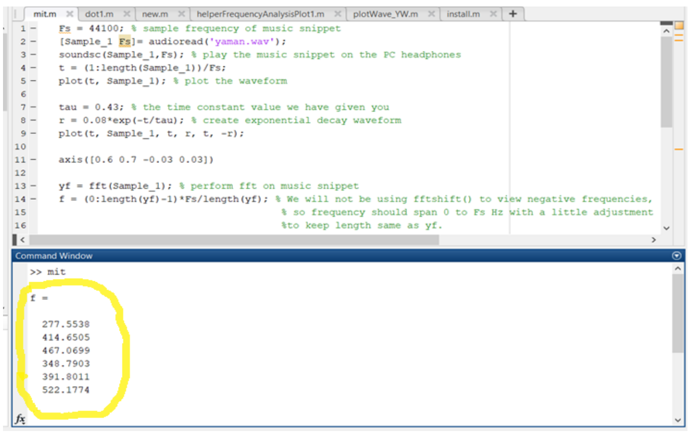

Fig -23: The corresponding frequencies of the isolated peaks

The resultant frequencies were close to 277.1, 311.5, 350.1, 391.2, 415.1, 465, 522.9, 553.8 Hz. These corresponds to the middle 'sa, re, ga, ma(tivra), pa, dha, ni, and high sa' respectively. Thus, we are able to deduct the notes that comprises in the 'Yamana raga'.

Now, implementing the same analysis on 'Twinkle-twinkle little star' tune. At first, figure 24 shows Magnitude on Y-axis and on X-axis, Time is represented in seconds.

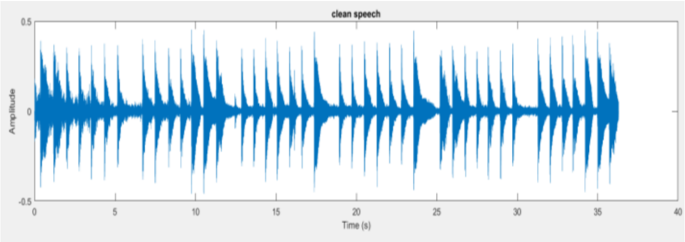

Fig -24: Amplitude vs Time for Twinkle-Twinkle

In the figure 25, shown below, spectrogram of the 'Twinkle-Twinkle' tune was conducted on the MATLAB software itself. Y-axis represents Frequency in Hertz x 10^4 and X-axis represents Time in seconds. We can observe that maximum overtone that can be included in the tune is around 12,000 Hz. Then, beyond 12,000 Hz, the energy is 0. Furthermore, at around lower frequencies till 1000 Hz the energies are maximum and beyond that the energy starts to fade.

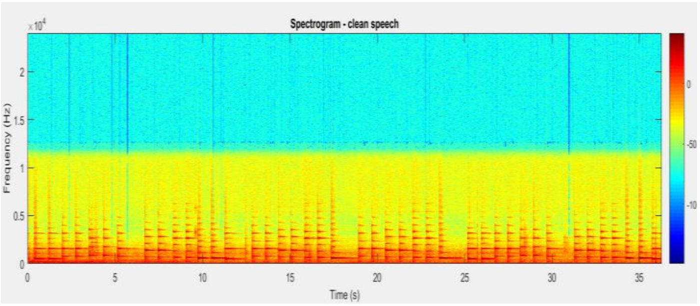

Fig -25: Spectrogram of Twinkle-Twinkle

In the Figure 26, the Fast Fourier Transform (FFT) of the raga, where in Y axis the loudness in dB is shown and the Frequency in kHz is shown. We can infer that the recording had a loudness of around 80dB. The sound ought to be louder because the speaker volume of keyboard was high

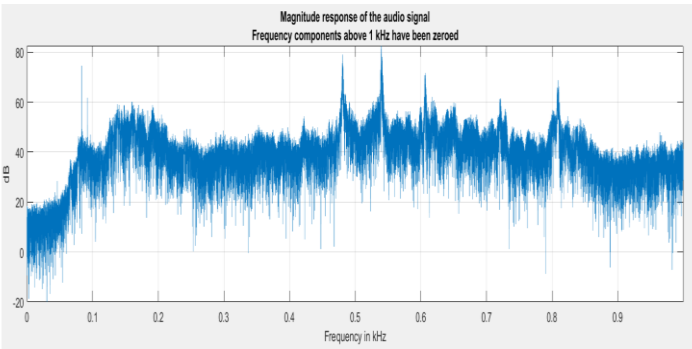

Fig -26: FFT of Twinkle-Twinkle

In the figure 27, we see some peaks and troughs throughout the graph. Selecting the peaks, helps us isolate those. These peaks are shown below in figure 28. The corresponding frequencies of these peaks are then shown as the result in MATLAB, depicted in figure 29. These frequencies when checked into the tables in figure 3 and 4, gives the keys that were pressed to make that particular tune.

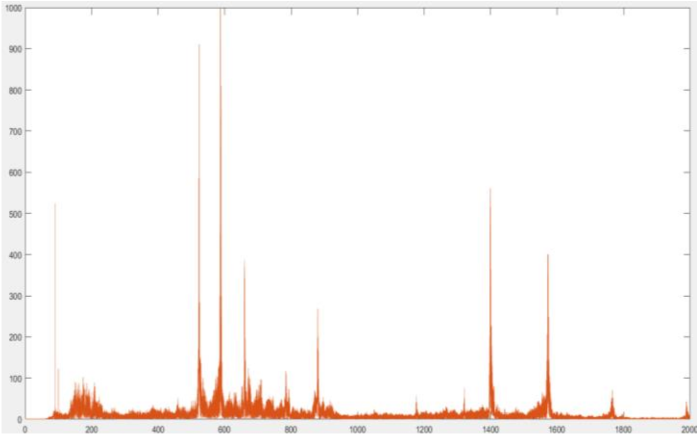

Fig -27: FFT (Magnitude vs Frequency) of Twinkle-Twinkle

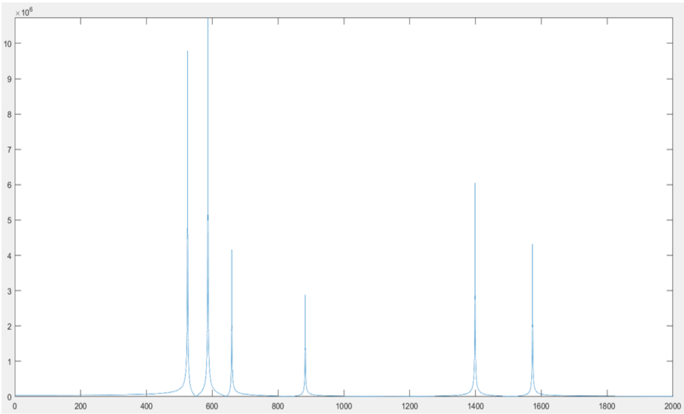

Fig -28: Isolated peaks for Twinkle-Twinkle

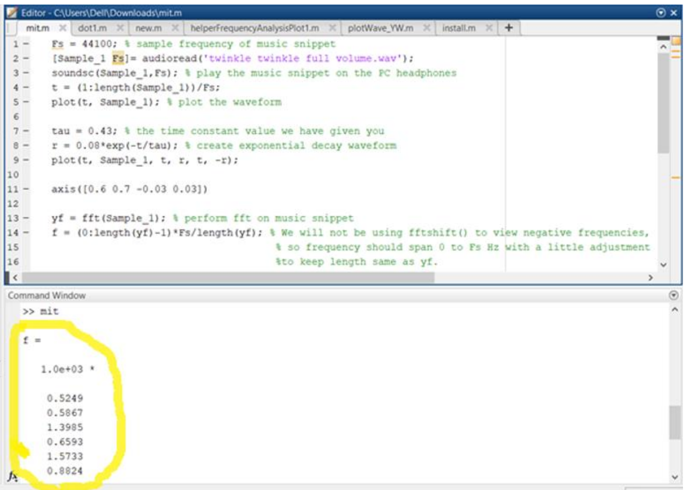

Fig -29: The corresponding frequencies of isolated peaks

The resultant frequencies were close to 522.5, 589.7, 660.2 881.1, 1402, and 1573 Hz. These corresponds to 'C5, D5, E5, A5, F6, and G6' respectively. Thus, we are able to deduct the notes that comprises in the 'Twinkle-Twinkle little star' tune.

There is a comparison shown between the note of Dha Komal (440Hz) on harmonium and A4 (440Hz) on the piano. Though both are harmonic in nature, there is difference in waveform as well as in the harmonics and their respective amplitude.

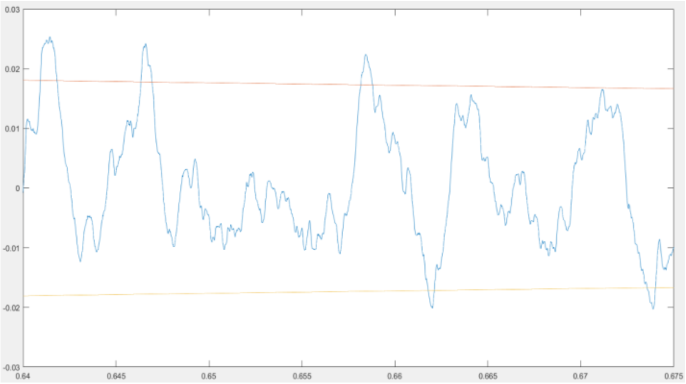

Fig -30: Dha Komal (440Hz)

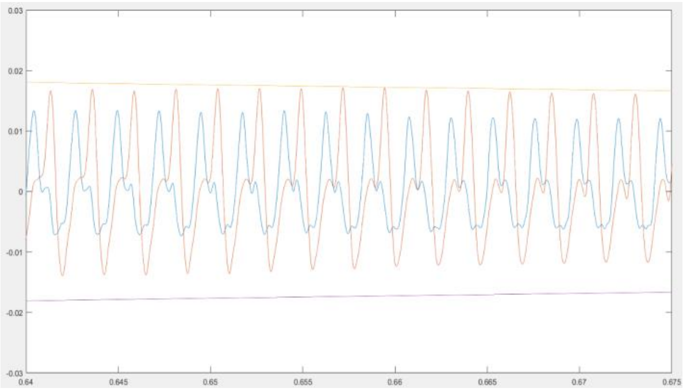

Fig -31: A4-440Hz

The figure 32 shows FFT analysis of Dha Komal played on harmonium, loudness is seeing reaching 80dB.

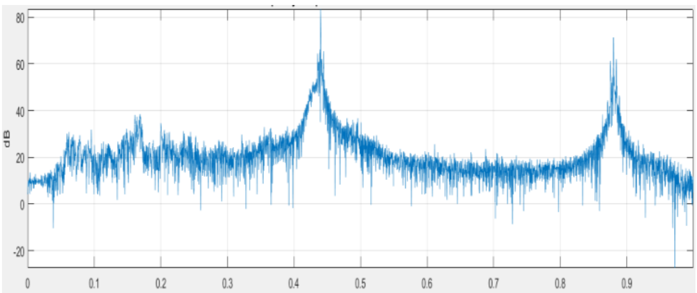

Fig -32: Loudness vs Frequency of Dha Komal

In the figure 34, we see that the harmonium key are continuous and do not decay with time like in the piano. Harmonium key when pressed can sound as long as you have kept pressing it.

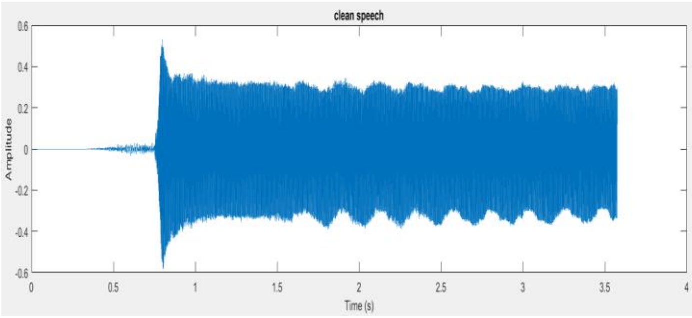

Fig -33: Amplitude vs Time of Dha Komal

In figure 34, spectrogram is shown. Initial there is 0 energy because the key was pressed after some time thus sound energy started later. Then we see that energy is never zero. Stable energy is seen for long time because of the reason stated above.

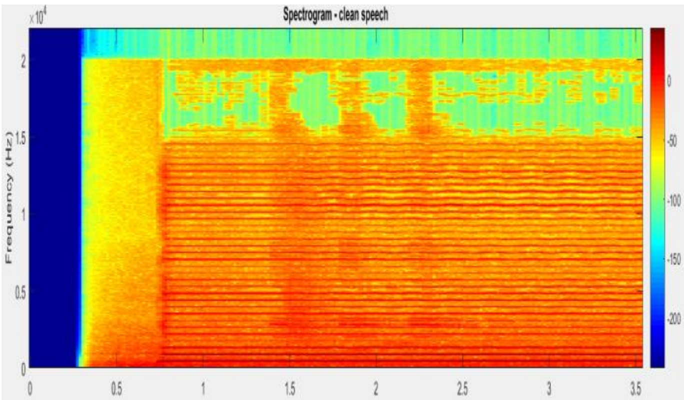

Fig -34: Spectrogram of Dha Komal

4. HUMAN EAR PERCEPTION

People have a quirk: it sees them relatively. For example, in the event that we played the A-220 key, and afterward the A-440 key, it "sees" that the vibration is twice as quick. This impression of relative pitches is called pitch interval. All pitch intervals, wherein one frequency is twice the other, feel the same. Numerous individuals can't see absolute frequencies, but see them relatively. If A-220 followed by A-440 is played, an audience will reveal to you that it seems like an octave, however he could not be able to find that you played the "A" keys on the piano. Another intriguing thing about our view of vibration frequencies and volume is that we see them on a logarithmic scale. Our ears distinguish changes in volume in a non-direct style. A distinction of 1 decibel is seen as a change in volume, 3 decibels is a moderate change, and 10 decibels is seen by the audience as a multiplying of volume. Piano permits to play substantially more sounds simultaneously. Assume that keys A-220 and A-440 are pressed on the piano. Utilizing the "bird" similarity:

a bird that hits the eardrum 220 times each second, another bird that hits it 440 times each second. Now, we play A-440 and E-660. This is not, a 2:1 vibration ratio, but is a ratio of 3:2. Utilizing the bird similarity, each 6th interval would get a hit from the two birds, each first and fifth will get no hits. The individual identifies this example and sees it as another characteristic pitch interval. Pythagoras mentioned a vital objective fact: sound pairs whose frequencies are connected by a basic ratio, are seen as a satisfying pitch interval. Vibration pair of frequencies in ratio of 2 to 1 sound pleasing. He considered it an octave. A ratio of 3 to 2 additionally sounds pleasing. He considered it a fifth, a ratio of 4 to 3 sounds to pleasing too which he considered it a fourth. A ratio of vibration frequencies of 21 to 17 would not sound lovely. A clarification for this might be that it is difficult for layman to grok a complex vibration design. The sound created by A-440 piano key will have a 440Hz sine-wave vibration part at high loudness, yet will likewise contain 660Hz and 880Hz sine-waves as overtones, at lesser loudness as seen from above analysis. The impact on human observation is that the resultant sound is rich, full and "rounded". The overtones concept similarly applies to artists. One artist has a more pleasant voice than another on the grounds that when he sings note A- 440Hz, his sound additionally has the overtones in different frequencies, that makes it sound full and rounded. Another vocalist may have an alternate mix of the overtones, which isn't as pleasant. Differences in the way various musical instruments sound can be explained in the same fashion. Instantly recognizable is the characteristic saxophone sound, or the violin sound, or the trumpet sound. Even if the same note A-440 is played on each of them, they sound very differently. This musical characteristic has a name: timbre. For instance, a high-pitched sound of A-880 will sound better on an alto sax than on a tenor sax. Likewise, it will sound better on a violin than on a contrabass.

5. DIFFERENCE IN SOUND OF INSTRUMENTS

Since we are already familiar with the harmonics, octaves, and overtones' concept, that will help us understand why do different instruments sound different. One of the notable differences which we could observe was that different musical instrument had same number of harmonics but the magnitude of each harmonic with respect to the fundamental key differed. For example, hypothetically speaking for piano A440 is fundamental key and its harmonics are 880, 1320, 1760 etc. and in the FFT, we find that A440, 1320, 880, 1760 respectively are in order of descending magnitudes. Taking another instrument like Acoustic Bass. For same fundamental frequency i.e. A440 and same harmonics the order of descending magnitudes are A440, 880, 1760, 1320. Thus, for same key we perceive different sound, because even if the key is comprised of same harmonics, their respective magnitudes are different in different instruments. The variety of a note or harmony over the long run is controlled by Lift, Dwell, and Return.

Rise is a proportion of the time. It shows the time it takes a note to arrive at its greatest magnitude. Instruments with short rise incorporate percussion, piano, and culled string instruments, for example, guitar or harpsichord. At the point when a note is played on these instruments, the sound rapidly arrives at its greatest level. Instruments prepared to do long rise incorporate woodwinds, brass, and bowed string instruments, for example, violins. Notes played on these instruments can begin calm and gradually work to their most extreme level.

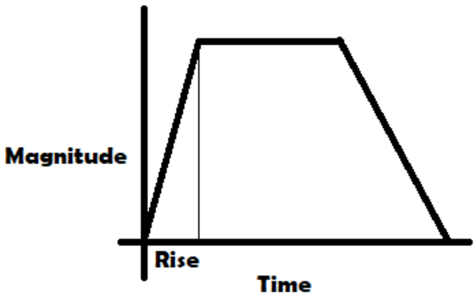

Fig -35: Short Rise

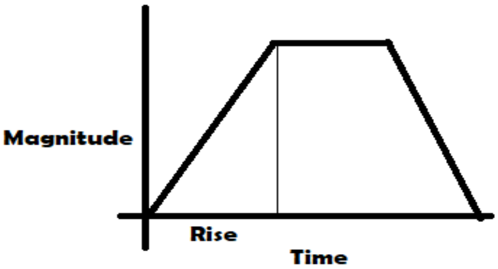

Fig -36: Long Rise

Dwell is a proportion of time, with regards to acoustic instruments. It shows the length of time that the consistent state extent of a note is held. Snare drums, banjos, and numerous other percussive instruments are instances of instruments with short dwell. When the note played and arrives at its greatest amplitude, it rapidly starts to return. Instruments, for example, electric guitar, bowed string instruments, and wind instruments are able to do long dwell. The artist can hold a note for a dwelled timeframe at a consistent state size.

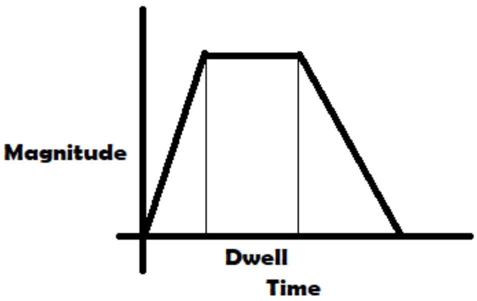

Fig -37: Short Dwell

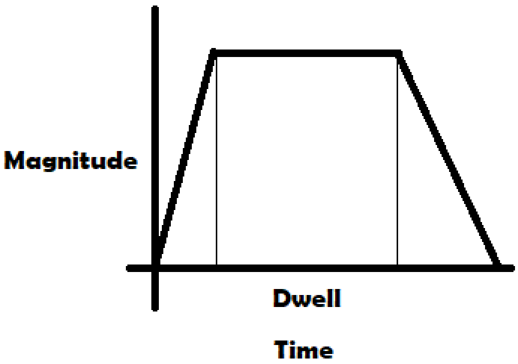

Fig -38: Long Dwell

Return is a proportion of the time. It shows the span of time a note takes to deteriorate from the consistent state power to finish quietness. Most percussion instruments have a short return. The power of the note rapidly falls after it the support time frame. Regardless of whether the instrument has a long continue time, it can have a short return time. For instance, a musician can hold a since quite a while ago, supported note and afterward suddenly quietness the instrument. Cymbals are one case of an instrument with a long return time. After the underlying strike, the force of a cymbal's sound gradually falls until it is totally quiet. Note that the performer playing the cymbal could abbreviate the return altogether by hushing the cymbal with their hand.

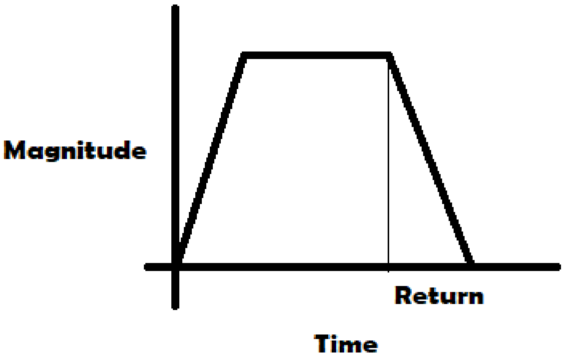

Fig -39: Short Return

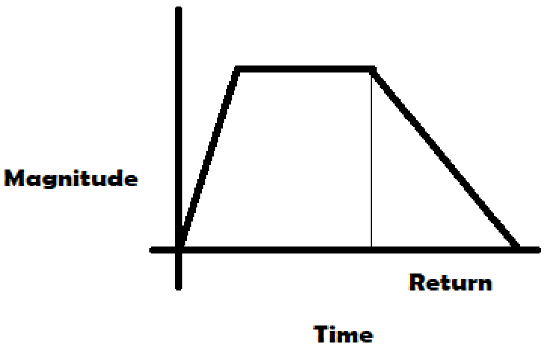

Fig -40: Long Return

6. CONCLUSION

In this project-based research, I was able to differentiate between A, B, D, E and G note on the basis of the sound characteristics by implementing FFT analysis on them. Further down, by doing FFT analysis on some notes of piano, I was able to study them properly. The spectrogram also gave much more information. After the notes, fundamental keys of the tune were successfully found out by FFT. Then how the same frequency keys sounded different was properly explained, also for this example of piano and harmonium was used with the key of 440Hz. There are definitely margins for errors as the recording were done in a room surrounded by normal walls, thus different environment sound would have an impact in the results. To achieve better results, specially made chambers and good equipment for recording to be used. In this project MATLAB codes were very basic, in future more complex codes could be exploited which could be used to analyze more parameters. For future works, creating a wide database which could be used for sound and tune recognition.

REFERENCE

[1] "Harmonium Raga Recognition" by Rajshri Pendekar, S. P. Mahajan, Rasika Mujumdar, Pranjali Ganoo, International Journal of Machine Learning and Computing, Vol. 3, No. 4, August 2013

[2] "Musical Note Segmentation Employing Combined Time and Frequency Analyses" by Gordana Velikic, Edward L. Titlebaum, Mark F. Bocko, 1988. ICASSP-88., 1988 International Conference on · June 2004

[3] "Musical Notes Identification using Digital Signal Processing" by Jay K. Patela, E.S. Gopia, 3rd International Conference on Recent Trends in Computing 2015 (ICRTC-2015)

[4] Massachusetts Institute of Technology Dept. of Electrical Engineering and Computer Science

[5] "Frequency analysis of acoustic signal using the Fast Fourier Transformation in MATLAB" Tomáš Harþarika *, Jozef Bockoa, Kristína Maslákováa, MMaMS 2012