Survey On Musical Scale Identification

Ranjana.S[1], Renisha.M[2], Mrs.A.Malathi[3]

[1] *Student, Department of Computer Science, Anand Institute of Higher Technology, Kazhipattur,*
[2]*Student, Department of Computer Science, Anand Institute of Higher Technology, Kazhipattur,*
[3]*Assistant Professor, Department of Computer Science, Anand Institute of Higher Technology, Kazhipattur.*

ABSTRACT:

Music is a combination of various components like Pitch, Swara, Raga, Jathi, Thala, Scale, etc through which the essence of tunes is generated. On considering scale, it has a unique feature of composing a tone with the reference frequency. The paper is entirely a survey of various music scale extraction mechanism by Digital Signal Processing. The concepts of how the machine learning technique has been applied in this method have been discussed. Further enhancement of this method leads to identify the scale automatically with a simple mathematical method by applying the concepts discussed in the existing system.

KEYWORDS:

Scale identification, Machine Learning, Digital signal processing.

1. INTRODUCTION

The medium of sound organized in time intervals is composed with combination of various elements and we denote that sound like music. The essence of sound rejuvenates a person. The combinations of effective parameters are considered as good music. The colour of music involves pitch, melody, rhythm, tempo, scale etc. According to the music theory, a composition of song is done by combining notes and arranging them sequentially to provide tunes which we denote as Raga in Indian culture. The melody generated will be generally played with certain scale. Most often the scale is built with single octave. The interval between one interval with another double frequency is considered as an octave. It is mostly represented in circular arrangement. In Indian Classical Music, the essence of sound includes sruthi, swara , raga and thala. The relative musical pitch or small gradation in pitch is available. The construction of scale, melodies and ragas are from selected pitches known as swara. To be more generic the sruthi is defined into seven per octave. As per Natya Shastra there are twenty two sruthi. In Western music, these sruthi are called as scale. Various categories like diatonic, chromatic, major and minor are included in scale.

When a song is effectively composed it should maintain a standard scale else the tune may be annoying at times. For any musicians knowing the scale of a song is very important since it makes up a good melodic sound. The instruments are always tuned with correct frequency values in order to maintain the scale to form an orchestra. To know the scale, musicians correlate with standard instruments like tanpura which will be tuned with the same frequency level. When the rhythm is played at faulty pitch then the entire melody will be affected. This faulty pitch is called as apasvara. On tuning the string or key instruments especially, we tend to strum each string or press each key to identify and match with the pattern generated for scale. This includes much time and also mismatch may occur frequently.

In reference to the book called "*South Indian Music" by Prof. P Shambamoorthy (Musicologist),* music is an exact science. The concepts are dealt with mathematical formulae. The fundamental notes are recognised by ratios. If one tonic note is identified the consecutive positions of other notes are identified. The dynamic system of music evolves the basis of aesthetic laws. Its accuracy and logic are designed based on anubhava(experience) and lakshya (practice)

The scales play a vital role since all music is composed based on a scale. Any orchestra checks their scale to synchronize the tunes. When a song is effectively composed it should maintain a standard scale else the tune may be annoying at times. For any musicians knowing the scale of a song is very important since it makes up a good melodic sound. To improvise the level of music or singing the pitch calculation and recognition is very much important. When the scale of the audio is known the level of performing becomes higher and efficient. The scale or Shruthi is generalised into twenty-two but when comparing with the 12-TET(*Fig1:12-TET tuning table*) (universal chromatic pitch classes) scale in western music, the sruthi is categorised into 12. The Sapthasvara or seven notes provide the major and

minor scale notes with unique frequency value. 53EDO provides the approximated sruthi. The 12 semitones used in an octave are universally known. The 72 heptatonic scales have been evolved with the basis of 12 notes. In addition to the heptatonic scales, Indian music enlists a huge number of transilient scales which deliberately avoids a note or two in ascent or decent or both. In European music, the melodic minor scale is a heterogeneous scale with the rank in the scheme of 5,184 and its suddha-misra melas are 1604. The octaves in Indian classical music is denoted as "Sa- Re-Ga- Ma-Pa- Dha –Ni". In western music, the notes are represented as "C-D-E-F-G-A-B".

The entire sounds are called dhwani. The chosen dhwani becomes the nada and from selected nada provides the sruthi. When few phrases from this sruthi are chosen then it becomes the swara for some Raga. Raga is the melodic tune of music. These Ragas are classified according to the six Chakra which includes Janya Ragas ie. Root Ragas. There are 72 Janya Ragas. Each chakra is grouped with six Janya Ragas or Melakartha Raga. A raga cannot have two consecutive sruthi. 10 pramana sruthi ie. Commas- 220 cents, 7 purna sruthi ie.limmas-630 cents and 5 nyuna sruthis-350 together makes up an octave.Totally 1200 cents are available.

Table 1- 12-TET TUNING TABLE

Shrutis				12-TET	
Name	Ratio	Cents	Frequency (Hz)	Name	Frequency (Hz)
Chandovatī	1	0	261.6256	C	261.6256
Dayāvatī	256/243	90	275.622		
Ranjanī	16/15	112	279.0673	C♯	277.1826
Raktikā	10/9	182	290.6951		
Raudrī	9/8	203	294.3288	D	293.6648
Krodhā	32/27	294	310.0747		
Vajrikā	6/5	316	313.9507	D♯	311.127
0Prasāriṇī	5/4	386	327.0319		
Prīti	81/64	407	331.1198	E	329.6275
Mārjanī	4/3	498	348.8341		
Kshiti	27/20	519	353.1945	F	349.2282
Raktā	45/32	590	367.9109		
Sandīpanī	729/512	612	372.5098	F♯	369.9944
Ālāpinī	3/2	702	392.4383	G	391.9954
Madantī	128/81	792	413.433		
Rohiṇī	8/5	814	418.6009	G♯	415.3047
Ramyā	5/3	884	436.0426		
Ugrā	27/16	906	441.4931	A	440
Ksobhinī	16/9	996	465.1121		
Tīvrā	9/5	1017	470.926	A♯	466.1638
Kumudvatī	15/8	1088	490.5479		
Mandā	243/128	1110	496.6798	B	493.8833
Chandovatī	2	1200	523.2511	C	523.2511

2. MATH

By referring to the "*South Indian Music",* the ratio calculation for notes are as follows

The following calculation involves arithmetic means and harmonic means.

ARITHMETIC MEAN = a+b/2
The arithmetic mean between

s and s = (1+2)/2 = 3/2 (Panchama)

s and p = (1+(3/2))/2 =5/4 (AntaraGandara)

s and antaragandara= (1+(5/4))/2= 9/8
(chatussruthiRi)

s and trisruthidha= (1+(5/3))/2=4/3(suddha Ma)

s and suddha ma= (1+(4/3))/2=7/6(a note below komala sadharanaga)

s and kaisikini = (1+(6/5))/2 =7/5(approx.. prati ma)

3. LITERATURE SURVEY

The Scales is fundamental to all music. In Ancient Greece, the scales are referred to as modes. Some commonly known scales are Major scale, Minor scale, Jazz sale, Blue scale etc. A Raga can be derived from a scale. It is a unique personality or distinct flavour which has no fixed rules precisely which combination. The ascendants and descendants in Indian classical music is called as Arohana and Avarohana. The home notes is named as Griha Swara, the dominant is called as Vaadi and Subdominant is called as Samvadi. The Dissonant is called as Vivaadi. The landing notes or resting notes is called as Nyaasa swara. Minimum an octave must consist of 5 notes at least in a Raga. Notes sung with 3 or 4 notes in an octave is very rarely performed. The root note is "Sa" and a Raga must use "Ma" or "Pa" by default. Either one of it or both can be used in the same raga. Other notes are exceptional. Various combinations can be performed using the octaves. To expertise in the concepts and to develop an algorithm, some more references were viewed and has been discussed below.

In Musical Notes Identification using Digital Signal Processing[1] paper, the input is taken as an audio file and it is processed to extract the features to identify the note of the song. To identify the

characteristic of the song, the digital signal processing techniques are used and has been explained. The piano songs are only allowed as input. The piano songs are used because the notes are known by us already, the identified notes and the original notes are compared until the higher rate is detected. This method used here for identification of notes is optimised than the previous methods. We can get the results by varying the parameters like threshold values and width, with time duration of each note. Thus it can be used as a tool for learning the notes of a song.

The input of this design only accepts the digitized waveform representing an acoustical music signal. The digital signal processing algorithm and its process are clarified by analyzing the above paper.

On referring a paper named Musical Note Recognition Using Minimum Spanning Tree Algorithm[2], the implementation of a musical note is done by making use of a separate software which recognizes music notes. The working of this software includes musical note image and output provides the information of musical note and beat's length sound of the recognized musical note. The processing involves four preprocessing steps namely Sobel edge detection, binarization, segmentation and scaling. Training process involves the result from the pre-processing methods. They present that their method provides an accuracy of 97.9 per cent. The entire paper deals with music signal processing where their software play an intelligent role in identifying the musical note. From this paper, we can be able to predict the methods followed for processing data values in numerical form or any image form to predict the scale automatically

In raga identification techniques for classifying Indian Classical Music: a survey paper[3], the properties of ICM(Indian Classical Music) are used for Raga identification. The various techniques are used to extraction the feature from Digital Signal Processing and Raga Identification for the Indian Classical Music classification are discussed. The several challenges are provided for the future work by this paper.

Linear Prediction Coefficients (LPC)and Mel Frequeny Ceptral Coefficient (MFCC) are considered as Timbre features. Adding on to the features for signal processing Short Term Fourier Transform (STFT) and Wavelet Transform (WT) is used. IN relating to the sound generation of music, the pitch determines the fundamental frequency. They have applied The Pitch Class Profile (PCP) and Harmonic Pitch Class Profile (HPCP) for melody extraction and note transcription. According to the research, misclassifications have occurred when ragas have same vaadi and samvadi.

Related to the survey of this paper we can say that the frequency extracted values can be passed as the entire feature vector for the prediction using Machine learning techniques like Support Vector Machine (SVM). For any music signal processing, MFCC is considered to identify the components of the audio signal by discarding the noises and pass the signal for further processing.

In reference to the paper, Raga Mining of Indian Music by Extracting Arohana-Avarohana Pattern[4], the analysis of sequence for raga identification is done. Here they compare raga mining with data mining for specific audio. According to this paper, the characteristic to the phrases (of notes), a sequence of notes, and the treatment given to each note in terms of its timing, rendition, prominence or ornamentation differentiate raga. They mention that identifying classical music by generating script is a tedious task. The system proposed by them has resulted in an accuracy of 95%.

From this, we can infer that based on the fundamental frequency and harmonic frequency the swara is been built. The notes of all swaras are related to ‘Sa’, from which ‘Shruti’ or ‘Scale’ of the song is identified. Fundamental frequencies of the scale were fixed to 240Hz. Once the Scale is known, the other notes based on frequency can be mapped according to the defined ratio into the 36 swaras of Mandra, Madhya and Taara saptaka.

By referring a paper, A literature review on content-based musical instrument recognition[5], music recognition task for real musical performance have been addressed. Multiple pitch extraction, automatic classification, and instrument recognition in music audio have been extracted to process the musical signal.

When recognition of notes and pitches comes into interactions, the basic outline of understanding the concepts of harmony, pitches, melody, harmony must be known. The impacts of these may cause a drastic change in the scale and this is clearly explained in the paper Signal Processing for Music Analysis[6]. It mentions the mathematical approach of STFT from which we can clearly understand that for any discontinuities in higher derivatives STFT will be effective to apply for information retrieval.

Based on the information above, the music scale has been identified by a deterministic walk method. Based on the nodes’ valid interval structure a transition state is been formed followed with validation that governs fragmentation of intervals. With a reference of this deterministic walk method

proposed in Musical Scales Recognition via Deterministic Walk in a Graph[7], we can correlate all the techniques mentioned above and combine as a wholesome picture.

In pyAudioAnalysis: An Open-Source Python Library for Audio Signal Analysis[8], is all about an open-source Python library that provides a wide range of audio analysis procedures including feature extraction, classification of audio signals, supervised and unsupervised segmentation. pyAudioAnalysis is licensed under the Apache License. This paper provided the implemented methodologies by the theoretical background, along with an evaluation of some metrics of the methods. In several audio analysis research applications uses the pyAudioAnalysis: speech emotion recognition, depression classification based on audiovisual features, smart-home functionalities through audio event detection, music segmentation, multimodal content-based movie recommendation and health applications such as monitoring eating habit. SVM regression map the audio features extracted from the previous steps to one or more supervised variables. The library also provides a semi-supervised silence removal functionality.

Based on the literature survey, future enhancements have been drafted.

4. FUTURE ENHANCEMENT

Currently,a musicians are in need of identifying the scale with short span of time and also due to the rapid social media development many people are interested to expose theirs in music. Hence from the above survey, an algorithm with simple mathematical formulae can be implemented. This algorithm can be used for identifying Raga in music and applied in Music Therapy.

5. CONCLUSION

The rationale of this paper is to present a review of various techniques involved in scale identification which can be embedded in various existing modules.The paper briefly gives an idea of feature extraction techniques and processing using The emphasis is given for finding real importance of scale and complexities in the existing work which can help the researchers for further progress.

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