RAGA IDENTIFICATION BY PAKAD MATCHING IN NORTH INDIAN CLASSICAL MUSIC

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ABSTRACT

Computational Musicology is new and emerging field of Data Mining. Raga is the most aspect of Indian Classical Music. It consists of unique set of notes (swara) and Pakad that correspond to a specific pitch. North Indian Classical Music has its root in Vedic ritual chants and has remained relatively untouched. Here, we depict a system that takes audio input file, convert it into sequence of notes and then find its most matching pattern. This pattern resembles with pakad of a raga and there by identifies the raga.

Index Terms: Raga, Pakad, North Indian Classical Music, Swara.

1. INTRODUCTION

Indian classical music is divided into Hindustani and Carnatic classical music according to difference between their characteristics. Hindustani classical music is Hindustani or North Indian style of Indian classical music. It is sometimes called as Shastriya Sangeet. North Indian classical music consists of two main elements Raga (melodic foundation) and Taal (rhythmic pattern). Raga is popularly known as a specified combination, decorated with embellishments and graceful consonances of notes within a mode which has the power of evoking a unique feeling distinct from all other joys and sorrows and which possesses something of a transcendental element [1]. In other word raga is the characteristic arrangement of notes which allow to uniquely identifying a raga. Swara is the particular note in a music which corresponds to the unique pitch and frequency.

North Indian classical music consists of 12 swara in a scale. The three main scales used in classical music are mandrya (lower), Madhya (middle), Taar-saptak (upper). The 12 swara viz. S, r, R, g, G, m, M, P, d, D, n and N are originated from 7 basic swara as S, R, G, M, P, D, N. A pakad is a characteristic phrase of a raga which allows it to uniquely identify from other. Pakad is a small
sequence of swaras in a raga that acts as a signature for the raga and an artist often visits and revisits the pakad over a performance [6, 10]. Each raga has different pakad from other raga. Pakad is defined as a condensed version of the characteristic arrangement of notes, peculiar to each Raga, which when repeated in a recital enables a listener to identify the Raga being played [1]. In simple word pakad is combination of swara sequence for a particular raga.

<table>
<thead>
<tr>
<th>Swara name</th>
<th>Swara (Indian Classical Music)</th>
<th>Note (Western Music)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shadja</td>
<td>S</td>
<td>C</td>
</tr>
<tr>
<td>Komal Rishabha</td>
<td>r</td>
<td>C#</td>
</tr>
<tr>
<td>Shuddha Rishabha</td>
<td>R</td>
<td>D</td>
</tr>
<tr>
<td>Komal Gandhara</td>
<td>g</td>
<td>D#</td>
</tr>
<tr>
<td>Shuddha Gandhara</td>
<td>G</td>
<td>E</td>
</tr>
<tr>
<td>Shuddha Madhyam</td>
<td>m</td>
<td>F</td>
</tr>
<tr>
<td>Tivra Madhyam</td>
<td>M</td>
<td>F#</td>
</tr>
<tr>
<td>Panchama</td>
<td>P</td>
<td>G</td>
</tr>
<tr>
<td>Komal Dhaivat</td>
<td>d</td>
<td>G#</td>
</tr>
<tr>
<td>Shuddha Dhaivat</td>
<td>D</td>
<td>A</td>
</tr>
<tr>
<td>Komal Nishada</td>
<td>n</td>
<td>A#</td>
</tr>
<tr>
<td>Shuddha Nishada</td>
<td>N</td>
<td>B</td>
</tr>
</tbody>
</table>

In this paper we wish to introduce you with some previous work. We focus on north Indian classical Music and not on Carnatic Music and Western Music. We propose method for note identification, then pakad identification and there by identifying a raga.

II. PREVIOUS WORK

Very less work has been done in the area of applying computational musicology for the North Indian Classical Music[1]. Of special interest for our work is work done by Gaurav Pandey, Chaitanya Mishra, and Paul Ipe [1], Prasad Reddy P.V.G.D, Tarakeswara Rao, Dr. K. R. Sudha, Hari CH.V.M.K, [4], Prasad Reddy P.V.G.D, Tarakeswara Rao,[5]. In their work Raga has been modeled as a finite automata using Hidden Markov Model, which were constructed using information available for particular raga in classical music. And this methods were enhanced using string matching methods with the use of pakad as a string. This approach was used for raga identification by providing some training of raga samples to Hidden Markov Model and after training use the system build from training each raga by HMM for raga recognition. Gopala Koduri, Sankalp Gulati, Preeti Rao [3] provided survey of different raga identification techniques and one of them constitutes techniques constructed by [1]. These techniques require more amount of time in training HMM for a particular raga and then using it with pakad matching algorithms. Instead of these direct pakad matching can be better way for faster recognition of a Raga.

It is most acceptable that “Pakad” is a catch phrase of a raga and each Raga has its unique and different pakad from other Raga [5]. Most people especially trained person have capability to identify a Raga being played by identifying pakad of a raga. Most of the time, pakad is not occurred as a continuous string sung in a raga. So pakad can be occurred in breaks and there is need to handle such sub string of pakad for identifying a raga. Since Pakad is very important part of performance in itself, a standard string matching algorithms are not guaranteed to work for pakad substrings. The approximate string matching algorithm designed by Costas S. Iliopoulos and Masahiro Kurokawa [2] with scope of bounded gaps for musical melody can be useful and more appropriate. The another
algorithm modeled by Domenico Cantone, Salvatore Cristofaro, and Simone Faro [7], can also be useful in the approximate matching of musical sequence with bounded gaps.

III. EASE OF USE

The proposed system aims at achieving an accuracy and performance. Here we depict a system which takes input as an audio file, identifies its pitch value using praat tool, convert it into sequence of notes, then uses pakad matching methods and identifies a raga.

![Block Diagram of the system](image)

Proposed system

The main objective of paper is to develop a system which automatically detects the raga of North Indian Classical Music. The fig. 1. shows the high level diagram of the proposed system. As a first step pitch detection is applied on audio file to generate text file containing pitch of the music with the help of praat tool. After that note identification is applied on that pitch file to generate sequence of swara/ note used in that audio file. This sequence of swara is given to pakad matching as a string of note to identify the corresponding raga of music or audio file.

The TABLE 2 shows the example of some ragas along with their pakad and collection of swaras in that raga.

<table>
<thead>
<tr>
<th>Raga</th>
<th>Swaras</th>
<th>Pakad</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bageshree</td>
<td>S, R, g, m, P, D, n, S’</td>
<td>‘D’nSm – gRS,nD mPD mg-mgRS</td>
</tr>
<tr>
<td>Bhairav</td>
<td>S, r, G, m, P, d, N, S’</td>
<td>Gm d-dP, m Gm r-S</td>
</tr>
<tr>
<td>Durga</td>
<td>S, R, m, P, D, S’</td>
<td>mPDP D-mRP- mR ‘DS</td>
</tr>
</tbody>
</table>

Note Identification

The note identification is the most important step in raga identification. If this step fails remaining all step for raga identification will be get failed. In North Indian classical Music notes/swara are allowed to spread over time for long duration in any composition, which complicate the task of note identification for North Indian Classical Music. In this step we present the some heuristic based on pitch of the input audio sample, which we used to determine notes from input sample. The pitch behavior allows us to identify note by using pitch features generated from pitch identification step.

The two heuristics based on pitch and execution time of performance are given below:

1) Pitch Slope Reversal Heuristic

This heuristic is based on the pitch feature of the music. It identifies the notes of the music based on hill and peak occurring in the pitch graph for corresponding music sample. The pitch for the given music sample is generated with the help of pitch detection tool as praat. A sample pitch graph obtained for an audio file from praat tool is given in fig.2 below.
Simultaneous observation of an music sample shows that note occurred at the point in a pitch graph of music where there is complete reversal of sign of slope or peak that is when there occurs hill after peak or vice versa. In some case note may occur at point where there is no complete reversal of sign slope. In mathematical consider that given input audio sample is associated with different time values $t_1, t_2, ..., t_i, ..., t_n$ and there corresponding pitch values are $p_1, p_2, ..., p_i, ..., p_n$. From this heuristic $t_i$ is the point of occurrence of a note when following equation satisfies:

$$\frac{p(i+1)-p(i)}{t(i+1)-t(i)} \frac{p(i)-p(i-1)}{t(i)-t(i-1)} > \epsilon$$

(1)

Once the point of occurrence of note is found the note can be found out by its closest characteristic pitch values. After performing this calculation for entire duration of music time we get the string of note.

2) Note Time Length Heuristic

This heuristic is based on assumption that in a performance of audio a note continues to occur for certain constant time span, and which depend on the type of music played. For example, most Indian Classical music consists of a note per 25ms. K is predefined constant which maintain the history list of last k notes identified in given music sample. The current note is accepted as a note from given sample if and only if it is different from the dominant note maintained in the history. Dominant note is the note which occurs more than m times in audio and value of m is maintained as constant value. Sample value of constants k and m are 10 and 8 resp. This test allows extending a note some time span represented by history. After performing this calculation for entire duration of music time we get the string of note.

Pakad Matching

Pakad is unique set of note sequence for each raga. The word "pakad" means 'the catch', 'the grip'; it 'catches' the nature and atmosphere of the raga; it gives us a way on how to best represent the raga. The raga is best represented by using its pakad. By assuming notes of raga we can resemble raga identification with word recognition problem and that pakad is considered as String, and collection of its substrings. Pakad matching can be applied by using similar to that of string matching methods. Different string matching algorithms are available. In our work, two methods for pakad matching are introduced.
3) N-gram matching:
This method counts the number of appearance of successive n-grams for a Pakad of a raga. Successive n-grams of a string are its substrings which are of length n [8, 9] which starts with beginning of the string and find the successive n-length string for given string till the end of string reach. For example, successive 2-grams of the string wxyz are wx, xy, and yz. Also, to allow for minor gaps between successive notes of the music, each n-gram is searched in a window of size 2n in the parent string. Based on this method, score I is maintained and is calculated using following formula:

\[
score I = \sum_{i=1}^{N} \sum_{j=1}^{M} F(j, i, l)
\]

4) δ- Occurrence with α-Bounded Gaps
This heuristic is based on assumption that a pakad in a raga I not obtained in its complete form of string always. The algorithm employs aspect of dynamic programming. It matches individual notes of music, say D, and previously known complete sample of note sequence for pakad, say S. The S will belong to D if and only if:
- There is a maximum difference of δ in between the current note of sample S and the next note of database D.
- The position of occurrence of the next note of database D in sample S is displaced from its ideal position by at most α.

This algorithm assumes that a piece from database (D) can be declared present in a audio sample(S) if and only if all notes of the piece (D) are present in the audio sample(S) within the specified bounds values of α and δ. This may not be true in our case because of some inaccuracy in note identification and note transcription step may not be accurate. Hence, for each Raga I in the consideration set, a given score is maintained and is calculated as follows:

\[
\gamma I = \frac{\text{max}(l)}{N(I)}, 1 \leq I \leq N\text{ragas}
\]

Where,
- max(I) = maximum number of notes of Pakad found in a given sample that Raga I.
- N(I) = total number of notes present in a Pakad of Raga I.
This score is used in the final determination of the Raga.

Raga Identification
Final identification of raga is done by using two steps:
- In δ-Occurrence with α-Bounded Gaps, the score values γI are sorted in increasing order and indices are set according to following condition.

\[
P(N\text{ragas}) > P(N\text{ragas} - 1), \text{and}
\]

\[
\frac{\gamma(I_{N\text{ragas}}) - \gamma(I_{N\text{ragas} - 1})}{\gamma(I_{N\text{ragas} - 1})} > N\eta
\]

Then,
\[\text{Index} = N\text{ragas}\]

- Otherwise, final determination is made on the basis of n-gram matching method score using following formula, where K is a predefined constant.

\[
\text{Index} = \text{argmax} \left( \log P \left( \frac{O}{\lambda I} \right) + K \times \text{score} I \right), 1 \leq I \leq N\text{ragas}
\]
IV. CONCLUSION

Thus in the given paper we introduced you with some basics needed for raga identification. The literature review containing previous work for pakad identification area is also described in this paper which provided us with the need and gap required to do the given work. The proposed system consists of the different methods of which note identification is essential and the pakad matching step provides the result for the system.

V. REFERENCES


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