Volume 5, Issue 5, May 2015 ISSN: 2277 128X

International Journal of Advanced Research in Computer Science and Software Engineering

Research Paper

Available online at: www.ijarcsse.com

Flute Melody Composition from Hindustani Vocal Music using Motifs Substitution Technique

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Abstract— In the music industry, synthesis of vocal sound tracks into instrumental melodies is an arduous and manual process that needs the input of musicians who are specialized in the target instruments. This process is rather expensive and time consuming. In this paper, we propose an automated means of transforming vocal sounds tracks to instrumental melodies that preserves the tonality and pitch of the original. This is done by the means of a technique that is introduced in this paper called the 'Motifs Substitution Technique". As a proof-of-concept, we show how we can convert vocal sound tracks sung in the Hindustani Classical style, which is a North Indian style of Indian Classical Music, into a flute melody.

Keywords— Music, Flute Melody, Vocal Music Transformation, Signal Processing

I. INTRODUCTION

Music has become one of the major parts in almost every person's life. Due to the latest technology and innovations, music's are very easily accessible. Gadgets like Walkman's, Mp3 players, iPod's, Smartphone's etc. made it very convenient for the people to listen all types of music in private. Although there has been advancement in music instruments technology, these instruments cannot produce music without any human efforts. Reducing this human effort at least by a fraction would be immensely appreciated by the music industry. In this paper an effort is done to automate the conversion of Hindustani vocal music to flute melody.

Indian classical music has two styles Carnatic and Hindustani. The Carnatic music is popular in southern part of the India and Hindustani music is popular in northern part of the India. Let's look at some of the characteristics of Hindustani classical music. The Hindustani music is based on the raag and its different characteristics. A raag is a melodic scale consisting of set of motifs or swaras.

A. Motifs, swaras, shrutis or notes

The sequential arrangement of motifs or notes defines the raag. The notes are called as swaras in Hindustani music. A motif is a fixed frequency value. The whole science behind the Hindustani music lies in the basic seven motifs, they are S(Sa), R(Re), G(Ga), M(Ma), P(Pa), D(Dha), N(Ni) which is similar to the C, D , E, F, G, B, A[1] of western music. The other motifs are slight variations in one of the seven motifs. In total there are 22 motifs in Hindustani music, S, r1, r2, R1, R2, g1, g2, G1, G2, M1, M2, m1, m2, P, d1, d2, D1, D2, n1, n2, N1, N2, S' [2]. A motif can be identified in an audio using Frequency Spectrum [3]. The frequency ratios of 22 motifs in Hindustani Music are shown in the Table 1[2].

Poorna Shruthi = 5.3497942 %
Pramana Shruthi = 1.25 %
Nyuna Shruthi = 4.166%

TABLE 1 FREQUENCY RATIO OF 22 SHRUTI'S

Shruthi	Type	Frequency
S	Poorna	100.00%
r1	Pramana	94.92%
r2	Nyuna	93.75%
R1	Pramana	90.00%
R2	Poorna	88.88%
g1	Pramana	84.37%
g2	Nyuna	83.33%
G1	Pramana	80.00%
G2	Poorna	79.01%

M1	Pramana	75.00%
M2	Nyuna	74.07%
m1	Pramana	71.11%
m2	Poorna	70.23%
P	Poorna	66.66%
d1	Pramana	63.28%
d2	Nyuna	62.50%
D1	Pramana	60.00%
D2	Poorna	59.25%
n1	Pramana	56.25%
n2	Nyuna	55.55%
N1	Pramana	53.33%
N2	Poorna	52.67%
S'	Poorna	50.00%

B. Arohana and Avarohana

Aarohana is a subset of raag motifs set which are organized in an ascending order. Avarohana is also a subset of raag motifs set but are organized in descending order. Both aarohana and avarohana describes the flow of the raag. The raag has its unique identity because of the combination of motifs in aarohana and avarohana.

C. Gamakas

Each motif is a fixed frequency value. The ghamak is formed by varying the pitch of a motif in such a way that, there is a continuous oscillation of the motif. Ghamak is an ornament to the raag.

D. Pakad

A Pakad is a commonly occurring repeated phrases (or collection of motifs), which uniquely identifies a raag. Each raag has its own set of pakad's. Pakad helps in identifying the raag of an audio track. Even musicians identify the raag, by observing the pakad's.

In this paper we have proposed the motifs substitution technique, which automatically forms the flute melody from a Hindustani vocal music. This is achieved by detecting the motifs sequence from the vocal music and substituting them with its equivalent flute motifs. Different phases of this technique have been discussed in detail.

II. SYSTEM OVERVIEW

The proposed system consists of five basic components as shown in Fig. 1, namely Vocal Pitch Detector (VPD), Flute Motifs Identifier (FMI), Vocal to Flute Melody Transformer (VFMT), Raag Detector (RD) and Out of Tune Melody Corrector (OTMC).

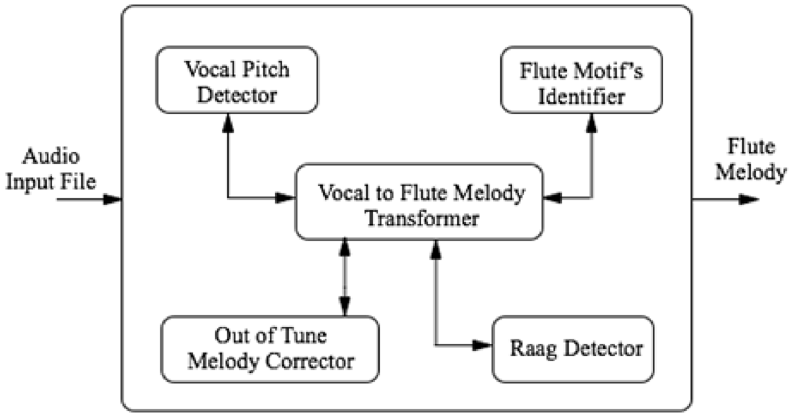

Fig. 1 Block diagram of the proposed System

III. MOTIFS SUBSTITUTION TECHNIQUE

Motifs substitution technique transforms the Hindustani vocal music to flute melody and works in following steps.

A. Vocal Pitch Detection

In Hindustani classical vocal music, the accompanying instruments will usually include the tabala, drone (tanpura), and the harmonium as well. The vocal track is usually superior compare to other tracks, because of which the vocal track can be extracted from the detected pitch of the predominant source. Vocal track detection involves tracking the pitch of the vocalist by identifying the vocal segments. The instruments such as harmonium and drone are strongly pitched. We therefore use a predominant-F0 extraction algorithm [1]. This algorithm is designed for robustness in the presence of pitched accompaniment. This method helps in identifying multiple pitch candidates for each segment of 10ms in the input music, by using the technique named spectral harmonics detection. Finally, the predominant F0 algorithm is selected based on a combination of temporal and spectral constraints.

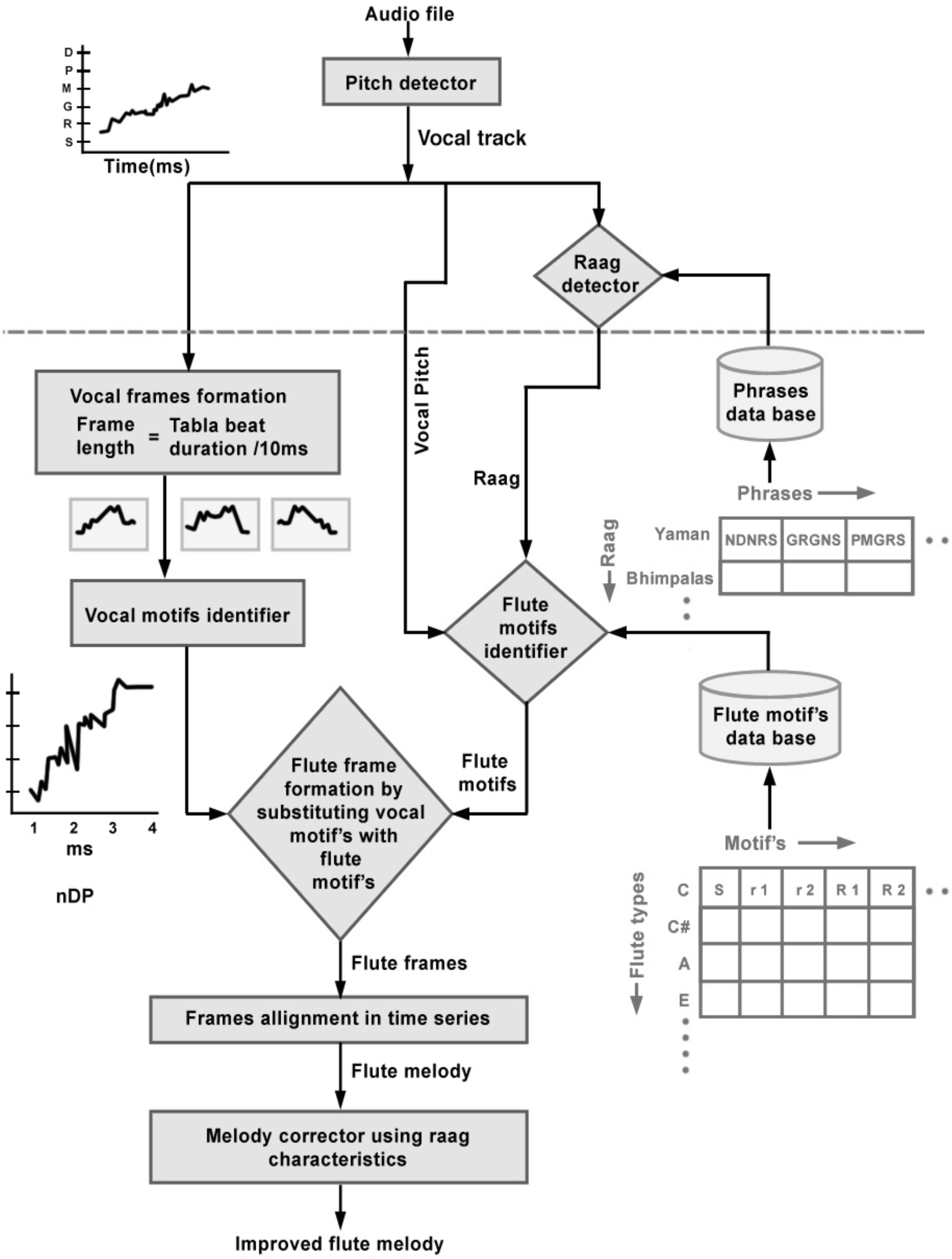

Fig. 2 Motifs substitution technique

B. Raag Identifier

There are many techniques available to identify an Indian classical music [5][6][7]. Commonly used technique to identify Hindustani raag is by identifying the pakad i.e. some of the commonly occurring repeated phrases in the track, which uniquely identifies the raag. For ex. In raag Yaman the commonly occurring phrases are NDNRS, GRGNS, PMGRS and so on. To identifying the Phrase, first we need to detect the nyas swara. The raag Yaman phrases ends with 'S' nyas. Joe Cheri Ross and Preeti Rao have discussed on Nyas swara detection and Phrase identification technique [6].

1) Nyas swara detection: Let us discuss this by considering raag Yaman as example. For raag yaman we should focus on 'S' nyas phrases. From the vocal track we scan the pitch contour for segments over which there is a less than 50 cents deviation from the 'S' swara value (or the fifth with respect to the tonic) over at least for a duration of 100 ms. The same constraint is checked for 150 ms following this segment except that now excursions outside the 50 cents range but limited to within 20 ms are permitted. Any gaps (silences) are included within the 150 ms. A segment that satisfies these criteria is labeled ‘S’ nyas swara.

2) *Phrase identification:* The nyas swara detected as above help to locate the boundaries of candidate phrases for the next step of phrase identification. The next task is to classify each candidate phrase into one or none of the characteristic phrases ending with the specific nyas swara.

C. Flute Motifs Identifier

The flute can be of many types differentiated by the pitch of the sound it produces. We need to set up a data base with the recorded motifs set for every such flute. The example for the flute types are C, C#, A, E etc based on the pitch of the melody it produces. The flute is selected based on the detected vocal pitch. All the motifs of the selected flute are retrieved and filtered based on the Raag, which is detected in previous step. Each raag has its own set of motifs. The filtered set of motifs will be used to form the final flute melody.

D. Vocal to Flute Melody Transformer

1) Frame formation: The sum instance of the tabala is important for any vocalist. For ex. A 16-beat cycle, group of 4 with 4 beat in each is divided as 'X(sum) 2   0(empty) 3'. The vocalist always aligns the mukhdha phrase according to tabala beats so that a fixed syllable coincides with the sum instant. Hence by detecting the beat instants in the music, the frames can be formed for each cycle. If tabala or tala in not accompanied in the audio then the frame of fixed length say 10ms can be formed.

2) Vocal Motifs Identifier: Each frame has to be scanned to find the occurrences of motifs between two beats using automatic motif detection technique [8][9] such as Frequency Spectrum[3] for Hindustani music. If there is no tabala accompanying the vocalist then the duration can be taken as 10ms. Within a single beat the motifs can vary from single note to multiple notes as S, SR, SRG, SRGM and so on. The motifs sequence table is formed from the identified motifs in the time series representation.

3) Motifs substitution: Next step is to substitute the vocal motifs with the equivalent flute motifs from the identified set of flute motifs in series. If any of the motifs frequency does not match with the flute motifs then the closest matching motif is selected.

4) Frames Alignment: Once the substitution is complete for all the frames, next step is to align the frames in time series. This sequence of flute motifs frames is the desired flute melody.

E. Out of Tune Melody Corrector

Using the raag characteristics information we can correct the flute melody to a large extent. This correction is directly proportional to the information on the raag which is collected.

IV. EXPERIMENTS AND DISCUSSION

We have experimented this technique for two Hindustani raags, Yaman and Bhupali. For any vocal track, in which base swara and pitch detection was perfect, the flute melody formed is almost identical to the original vocal track. The flute melody formed sounds perfect when heard by the common people. But expert musicians suggested to improve upon retaining the original mood and naturalness of the track. To improve this we can expand our flute data base with the variations of same motifs set for different moods.

The comparison between original vocal track with transformed flute track is shown in Fig. 3. The motifs sequence in the track is “SGRS_DSR GGPGDPGR” and is in theen thaal. The transformed flute melody is formed with exactly same motifs sequence. The visible difference seen in the graph is due to the difference in the loudness. We need to improve the smoothness at the junction where the two frames are aligned so that there are no small jerks between the frames.

For better results the techniques mentioned in different phases can be replaced with the efficient techniques based on the set of input tracks used. For instance, phrase based raag detection technique can be changed to aaroha/avaroha based raag detection, for the raag which cannot be detected based on the pakad.

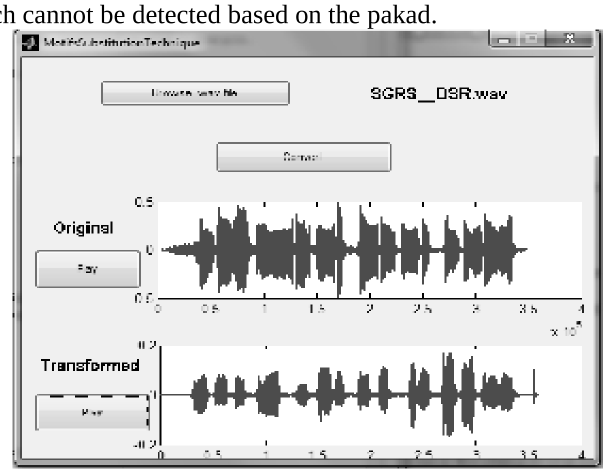

Fig. 3 Frequency graph comparison between original voice track and transformed flute track.

V. CONCLUSIONS

In this paper we have proposed an automated mechanism for transforming vocal sound tracks to instrumental melodies. We introduced a technique called the 'Motifs substitution technique' which can perform the transformation with minimal deviation of pitch and tonality from the original sound track. We have demonstrated a proof-of-concept of this technique by applying it to a Hindustani Classical vocal track and transforming it to a flute melody.

The proposed technique comprises of 2 major phases. In the first phase we make use of the existing 'predominant-F0 extraction pitch detection algorithm' to extract the vocal and tabala track and 'pakad based raag detection technique' to identify the raag. In the second phase we use Motifs substitution technique which comprises of four different techniques which includes 1. Flute Motifs Identification 2. Vocal Motifs to Flute Motifs Mapping 3. Flute Melody Formation and 4. Melody Fine-tuning

Future work includes generalizing this technique to convert sound tracks to the melody of any other musical instruments. This can be achieved by implementing databases for the respective instruments and comparison mechanism. Future work also includes analyzing the performance of this technique with respect to actual instrumental music's.

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