Proc. of the Int. Sym. Frontiers of Research on Speech and Music (FRSM)
13-14 March 2014, AIISH Mysore, India, pp. 91-95.

TEMPO DEPENDENCE OF MELODIC SHAPES IN HINDUSTANI CLASSICAL MUSIC

Kaustuv Kanti Ganguli and **Preeti Rao**

Department of Electrical Engineering
Indian Institute of Technology Bombay, Mumbai 400076, India
{kaustuvkanti, prao}@ee.iitb.ac.in

Abstract- *The melodic progression in raga performances in Hindustani music comprises recurrence of the raga characteristic phrases. The precise phrase intonation is so crucial that it acts as a major cue to raga identification by listeners and is well accepted as the foundational unit of a raga in the pedagogical tradition as well. Though the melodic motifs often hold unique canonical forms, phrases do show pitch and temporal variability across instances. We focus on finding the effect of tempo alteration on the temporal characteristics of the melodic shapes. We validate our hypothesis that there is a non-linearity in the phrase elongation/ compression across a range of tempi. We also study the consequence of phrase level modifications on the transitory segments like a meend. This provides an interesting insight on the source of improvisation on a melodic motif while introducing an avenue for evaluation of music scholars' performance in a MIR scenario.*

Keywords- Raga characteristic phrase, Tempo, Sub-segments of a phrase.

1. Introduction

Indian classical music is predominantly an improvisatory form of tonal music. The core of the Hindustani music tradition is grounded in the melodic and rhythmic framework of *raga* and *tala* [1]. The elementary building blocks for a *raga* elaboration are the melodic phrases. Though a characteristic phrase (also referred to as *pakad*) of a *raga* often holds a unique canonical form, considerable variability is observed among the instances of the same phrase in a *raga* performance. This variation usually involves multiple dimensionalities, such as pitch, time, timbre, energy dynamics etc. It is implied that these phrases are still highly recognizable by trained listeners [1]. In two dimensions (pitch vs. time), the captured similarity among phrases is either local or global. Repeated use of the same melodic motif (with its inherent variability) around the same *nyas svara* is observed during the *vistar* region [2]. This emphasis helps the artiste establish the notes in course of the gradual unfolding of the *raga*. Relatively less pitch and temporal variability among the *mukhda* phrases is used as a cue to the *mukhda* identification in [3]. In this paper, we focus on the effect of tempo variation on the temporal characteristics of a phrase.

'Tempo' by itself is a loaded term and finds diverse interpretations in different cultural context. Also, there lies a subjectivity in its perception. For example, the surface rhythm of the accompaniment also differs from the absolute tempo quite often in a performance. In Hindustani classical music, tempo is defined in terms of the cycle length of a certain *tala*. The nature of *raga vistar* depends heavily on the tempo. Same phrase rendered in a fast tempo might not carry detailed attributes of the phrase. More interestingly, direct correspondence between the tempo of the percussion accompaniment and the pace of melodic progression of the singer is not observed to be very consistent. A critical study on the *vilambit*/ *madhyalaya gayaki* [4] and intrinsic *laya* of the *raga* [5] might be useful.

We address the question of the tempo dependence of the characteristic phrases (*pakad*) of a *raga*, both, in terms of total phrase duration and the durations of the sub-segments that it comprises. We hypothesize that the steady notes are elongated/ shortened roughly proportional to the absolute tempo and the *nyas svara*s can be elongated even more depending on the context. We study the consequence of the phrase level modifications on the transitory segments such as the *meend*/ *aandolan*/ *kan*. In this work, we first discuss our database and phrase annotation. In the consequent sections, we talk about the audio processing and melody segmentation, experimental results are shown in support of our hypotheses, finally we conclude and propose an extension of the idea as future work.

2. Database & Annotation

The tempo dependence of the melodic shapes is studied through one song in *raga* Deshkar by Kishori Amonkar and a set of 10 selected performances of *raga* Alhaiya Bilawal by eminent Hindustani vocalists, as described in Table 1. The motivation for choosing *raga* Alhaiya Bilawal is the repeated appearance of its typical phrases in the *raga vistar*. The songs comprise of a vast range of tempi. Manual phrase annotation was done in PRAAT audio interface as discussed in [6].

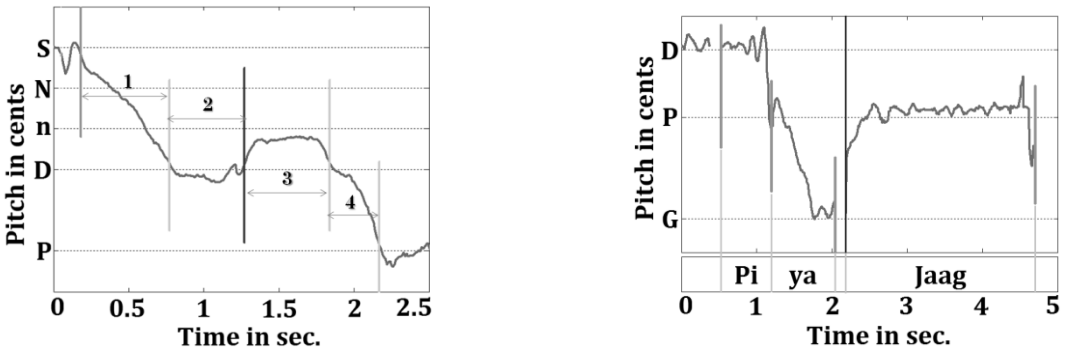
Raga	**Song ID**	**Artiste**	***Tala***	***Laya***	***Bandish***	**Tempo (bpm)**	**Dur. (min)**	**Average duration in sec. (no. of phrases)**		
								DnDP	***mnDP***	***GRGP***
Alhaiya Bilawal	AB	Ashwini Bhide	Tintaal	Madhya	Kavana Batariya	128	8.85	1.598 (15)	1.41 (31)	**3.074** (5)
	MA	Manjiri Asanare	Tintaal	Vilambit	Dainyaa Kaahaan	33	6.9	1.974 (12)	1.186 (11)	2.308 (6)
	RK	Rashid Khan	Tintaal	Drut	Sumiran Bhaj Mana	160	7.3	1.148 (17)	**0.677** (16)	1.41 (9)
	SS	Shruti Sadolikar	Tintaal	Madhya	Kavana Batariya	150	4.15	1.476 (3)	**1.586** (14)	1.606 (3)
	KG	Kumar Gandharv	Tintaal	Drut	Laita Jaiyo	174	6.43	**0.855** (11)	0.715 (12)	**0.63** (1)
	ARK	Abdul Rashid Khan	Jhaptaal	Madhya	Kahe Ko Garabh	87	11.9	1.346 (10)	-	2.737 (14)
	DV	Dattatreya Velankar	Tintaal	Vilambit	Dainyaa Kaahaan	35	18.3	**2.074** (16)	0.805 (4)	2.253 (9)
	JR	Jasraj	Ektaal	Vilambit	Dainyaa Kaahaan	13	22.25	1.26 (36)	-	1.744 (29)
	AK-1	Aslam Khan	Jhumra	Vilambit	Mangta Hoon Tere	19	8.06	1.234 (10)	1.232 (8)	2.08 (6)
	AK-2	Aslam Khan	Jhaptaal	Madhya	E Ha Jashoda	112	5.7	1.272 (7)	-	1.726 (3)

Table 1. Description of the audios in *raga* Alhaiya Bilawal and relevant metadata. The phrase durations are calculated after truncating the P-*nyas svara* at the end (for all 3 phrases), as this had unpredictable length and could be arbitrarily elongated depending on the context.

2. Audio Processing

Melody extraction from a polyphonic audio is a challenging task. [7] employed a predominant-F0 detection algorithm in presence of pitched accompaniment. Finally we obtain the predominant melodic contour based on a combination of spectral and temporal constraints. This time-series data (pitch vs. time) is referred to as the pitch curve which comprises a chain of melodic shapes.

We further segment the time-series pitch data into sequence of silence, steady note segment and transient pitch segment between steady notes. An automatic segmentation algorithm helps get the onset or off-set of any desired steady note segment, based on hysteresis thresholding. The threshold and hysteresis distance used is typically 20 and 50 cents from the equal-tempered location of each note. Figure 1(a) shows the sub-segments obtained from one instance of the DnDP phrase in *raga* Alhaiya Bilawal by Ashwini Bhide. The four sub-segments correspond to: (1) glide from 'S' to 'D', (2) steady note 'D', (3) 'n' with transition from and back to 'D', (4) steady note 'D' till the onset of 'P'-*nyas* (sometimes having a *kan svara* of 'n' just before the onset of 'P').



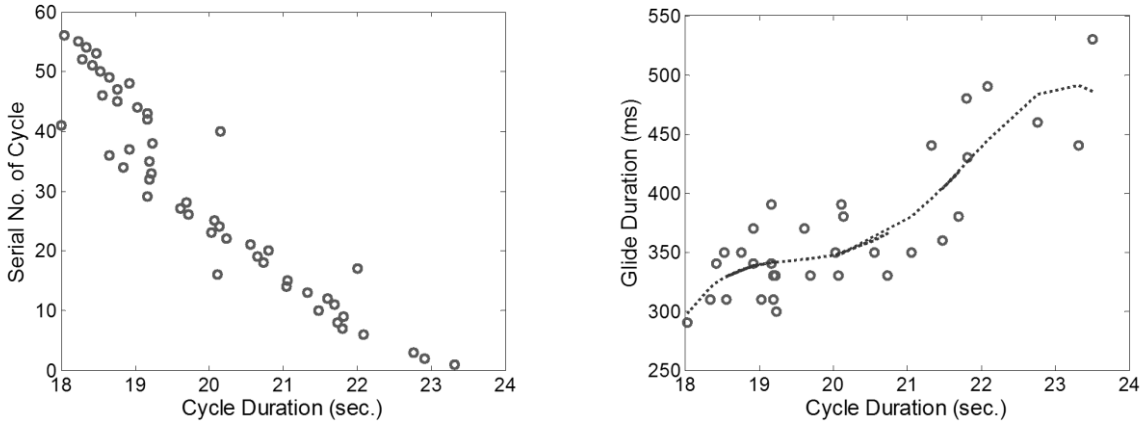
(a) (b)

Figure 1. Pitch curves for (a) Sub-segments of a phrase: *svara* onsets and offsets (vertical bars) in a DnDP phrase. Dark bars: exiting a *svara* by descending/ ascending; light bars: approaching a *svara* from below/ above. The segments marked 1 through 4, is used in the experiment (Section 3.2.1); (b) *Mukhda* phrase of *bandish* in *raga* Deshkar: the lyric is shown on the bottom tier. the dark vertical bar shows the location of the *sam* beat, the syllable 'ya' is considered for the experiment (Section 3.1)

3. Experimental Results

3.1. *Mukhda* Phrase

The *mukhda* phrase is chosen in support of the musical knowledge that these phrases are meant to be rendered with most insignificant variations across instances. We study the 'P' to 'G' glide (refer to Figure 1 (b)), being a consistent part of the *mukhda* of the *bandish* 'Piya Jaag', by Kishori Amonkar in *raga* Deshkar to observe whether the glide duration has any correspondence with the varying tempo across the concert. The tempo varies from 23.32 sec/cycle to 18.01 sec/cycle through 56 cycles. Figure 2 shows the profile of the glide duration with respect to the *tala* cycle length along the length of the audio excerpt. We observe a clear non-linearity in the glide duration profile as in (b).



(a) (b)

Figure 2. Piya Jaag in *raga* Deshkar by Kishori Amonkar: (a) Tempo variation profile along the length of the audio excerpt, (b) Duration of the 'P' to 'G' glide in the *mukhda* phrase of the corresponding *tala* cycle, the dotted line is the best fitted curve with polynomial degree = 4

3.2. Characteristic phrase (*pakad*)

This class of phrases is chosen with the musical knowledge that these phrases are rendered with quite high constraints in terms of intonation variations as compared to other phrases. We compare the average durations of 3 phrases (DnDP, mnDP, GRGP) with end boundary set at the onset of the P-*nyas*. No correspondence of the average phrase duration with the *tala* cycle length is observed to be

consistent, as shown in Table 1. In support we show in Figure 3, pitch curves of the same phrase DnDP from 3 different singers. We observe that the phrase duration is almost equivalent for all 4 phrases, irrespective of the tempi being different for all.

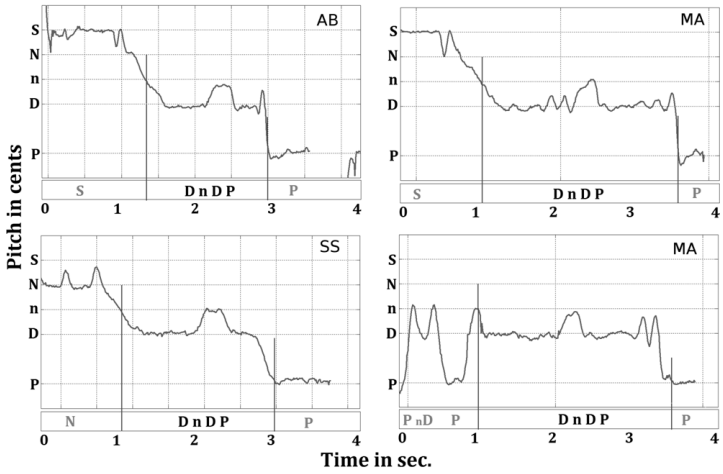


Figure 3. Instances of the DnDP phrase in *raga* Alhaiya Bilawal by 3 different artistes (AB, MA and SS) from the database (refer to Table 1). The vertical bars show the beats of the *tala* cycle. We see that the phrase duration is almost equivalent for all phrases, irrespective of the tempi of the songs

3.2.1. Sub-segments of a phrase

We obtain the sub-segments of each phrase by the algorithm as discussed in Section 2 (Figure 1 (a)). We observe the distribution of the absolute durations of the sub-segments of all 25 DnDP phrases rendered by Ashwini Bhide and Manjiri Asanare. The distribution shows that some segments (typically Segment 4 and also Segment 2 to some extent) are widely distributed, while other two (Segments 1 and 3) are quite narrow. This validates our hypothesis that the transitory sections are quite consistent in their intonation in any part of the concert and any tempo. It can be commented that artistes take liberty to elongate the steady segments though maintaining the raga rules and aesthetics.

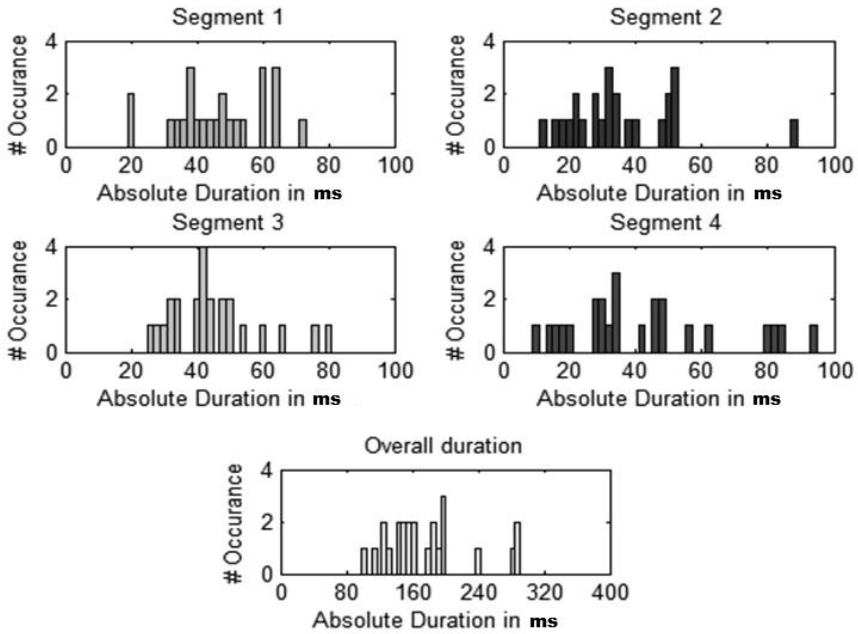


Figure 4. Distribution of the absolute duration of the sub-segments (top 4) and overall phrase (bottom) of the 25 DnDP phrases from the audios of AB and MA. The overall phrase duration also has a narrow distribution even though the tempi of the two songs are quite different (128 and 33 bpm)

Figure 4 indicates that the transient pitch curves have almost consistent behavior in terms of absolute duration, even if the underlying tempi change. This confirms the non-linearity in the stretch of pitch segments of a melodic curve with respect to the tempo variations.

4. Conclusion & Future work

The *raga* characteristic phrases are essentially garlanded during the *raga vistar* in Hindustani classical music tradition. This makes the representation of melodic phrases and their similarity characterization crucial for music retrieval for Indian classical music [6]. We considered the annotated melodic phrases and an automatic segmentation of the same, to observe the dependence of the melodic shapes on the tempo of the performance (in terms of the *tala* cycle length). We summarize the experimental results to validate our hypotheses and conclude the following:

- There is no definite correspondence between a phrase length & *tala* cycle length.
- The change in absolute duration of a phrase is not equally distributed amongst its sub-segments.
- Mostly glides (transitory parts) are held constant, steady notes absorb the compression/ expansion.

As future work, we propose to carry out similar experiments for the other annotated phrases of the same audio as well as other audio performances of the same *raga*. We would like to include phrases with characteristic glides of other *raga*s to generalize the observed behavior. [8] has proposed a methodology for automatic extraction of *meend* from a performance of Hindustani classical music. [9] has investigated shapes of the melodic curves to characterize pitch movements in morning and evening *raga*s, in a statistical approach. We aim to carry out similar task on our database towards the development of an enriched melody representation and transcription of an audio excerpt. We would also like to obtain a correlation between phrase duration and the 'singing tempo' rather than defining tempo of a concert in terms of the *tala* cycle length. Another goal would be to model the phrases in terms of melodic shapes with definite mathematical descriptors.

Acknowledgement

This work received partial funding from the European Research Council under the European Union's Seventh Framework Programme (FP7/2007-2013)/ ERC grant agreement 267583 (CompMusic).

References

[1] P. Rao, J.C. Ross and K.K. Ganguli, "Classification of Melodic Motifs in Raga Music with Time-series Matching," *Ninaad*, Vol. 26-27, pp. 59-68, December 2013.

[2] K.K. Ganguli, "How do we 'See' & 'Say' a Raga: A Perspective Canvas," *Samakalika Sangeetham*, Vol. 4, No. 2, pp. 112-119, 2013.

[3] J.C. Ross, T.P. Vinutha and P. Rao, "Detecting melodic motifs from audio for Hindustani classical music," *Proc. of Int. Soc. for Music Information Retrieval Conf. (ISMIR)*, 2012.

[4] K.K. Ganguli, "Guruji Padmashree Pt. Ajoy Chakrabarty: As I have seen Him," *Samakalika Sangeetham*, Vol. 3, No. 2, pp. 93-100, 2012.

[5] S. Kulkarni and U. Arunachalam, *Shyamrao Gharana*, Prism Books Pvt. Ltd, Volume 1, 2011.

[6] P. Rao, J.C. Ross, and K.K. Ganguli, "Distinguishing raga-specific intonation of phrases with audio analysis," Manuscript accepted for publication, in press.

[7] V. Rao and P. Rao, "Vocal Melody Extraction in the Presence of Pitched Accompaniment in Polyphonic Music," *IEEE Trans. Audio Speech and Language Processing*, Vol. 18, No.8, 2010.

[8] A. Datta, R. Sengupta, N. Dey, and D. Nag, "A methodology for automatic extraction of '*meend*' from the performances in Hindustani vocal music," *Ninaad Journal of ITC Sangeet Research Academy*, Vol. 21, pp. 24-31, December 2007.

[9] S. Chakraborty, "An interesting comparison between a morning raga with an evening one using graphical statistics," *Philomusica on-line*, Vol. 7, 2008.