Improved Methodology of Raga Discrimination in north Indian Classical Music by the Method of Correlation of Frequency Distribution of Pitch Profiles

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ABSTRACT

Pitch profiles of total 76 songs of 4 ragas of north Indian classical music, sung by 19 musicians of varied expertise were considered for the present work. Correlation of the distributions of those profiles were calculated, both self and cross, to detect similarities and dissimilarities exhibited by inspecting the correlation values. The results show, in general, high values of correlation between songs of same raga but low values between songs of different ragas. The work is basically extension of our previous work [1] but with a modified method and with larger database. The result shows great improvement over the previous result.

INTRODUCTION

Raga in Hindustani classical music is defined, among other things, by a set of notes those are permitted to be used. However a few ragas use the same set of notes, but their relative abundances of usages are different. There are other distinguishing features e.g. phrases, 'chalans', 'pakads', etc. In the present study investigation is done about the first parameter, i.e. the relative abundance of the usage time of the notes. Frequency distribution of the time a note is sung in a song may be supposed to reflect the relative use of the sung note. Such a representative frequency distribution constructed from pitch profile of the song may be assumed to reflect objectively the raga, in some sense.

The table below gives the grammatically allowed notes for the four raga under consideration. This is only for an idea and comparison with relevant portion of the analysis done here, but actually this information is not needed and hence not used here.

Raga	Suddha Swara	Vikrit Swara
Bhairav	Sa, Ga, Ma, Pa, Ni	re, dha
Darbari Kannada	Sa, Re, Ma, Pa	ga, dha, ni
Mian-ki-Mallhar	Sa, Re, Ma, Pa, Dha, Ni	ga, ni
Todi	Sa, Pa, Ni	re, ga, MA, dha

EXPERIMENTAL DETAILS

The *aalap* part of each song was selected excluding the bandish part. Duration of each selected part is ~3 to 5 minutes. Each song was digitized at the rate of 22500 samples/sec., 16 bits/sample. Standard noise cleaning and amplitude normalization was done for each signal file. The pitch profile is extracted using state-phase approach [2], which gives pitch values (in Hz.) for each pitch period and were stored as 76 'cep files' (4 ragas of each of 19 singers). Smoothing operation [3] was done on each of the above pitch pattern files. The resulting pitch profiles were put into 76 'pit files'. A skilled musician listened to the signal files one after another to perceptually detect the position of tonic (Sa) in the file. By FFT analysis, using a standard software package, at the detected region, Sa for the respective signal file was calculated.

All pitch values in each pitch profile is divided by the Sa of the respective singer and is folded back to middle octave (1 to less than 2), if necessary. The inverse of pitch periods converted in millisecond are used as durational values. The whole octave is divided into 1200 bins of width 1 cent. Frequency distribution of these ratios in a raga uses the total time corresponding to the pitch values in each bin.

A software was developed and used to detect the peak of the distribution around the theoretical note positions for all the 12 notes and 25 cents on either side of the peak position from the distribution was retained.

Figures below show examples of frequency distributions of modified pitch profiles (as described above) for all the 4 ragas, pair wise for original and truncated version of the distributions.
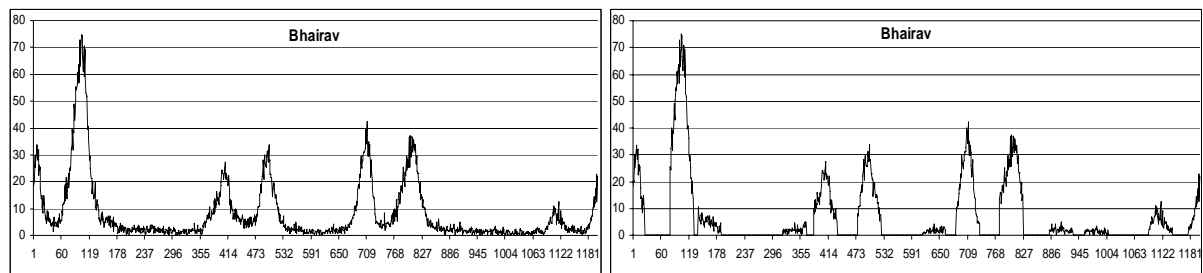

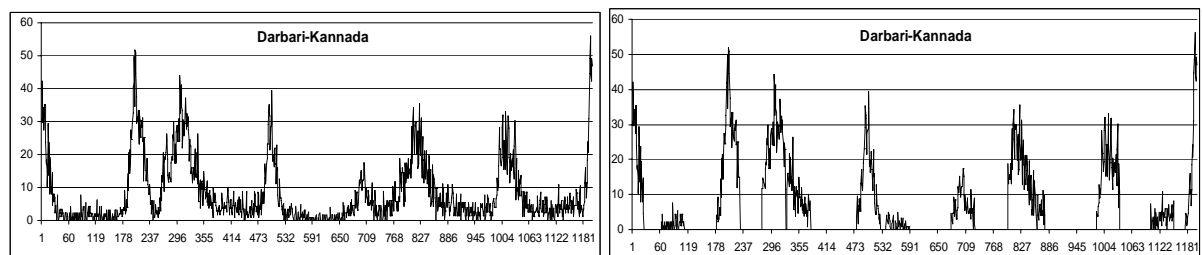**Figure 1 : Distribution of Bhairav.**

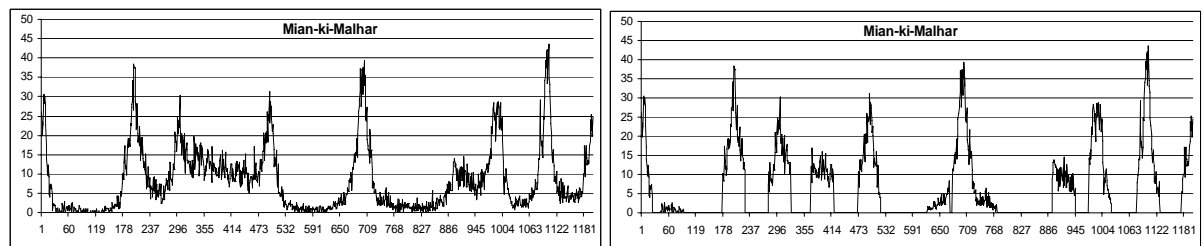**Figure 2 : Distribution of Darbari Kannada.**

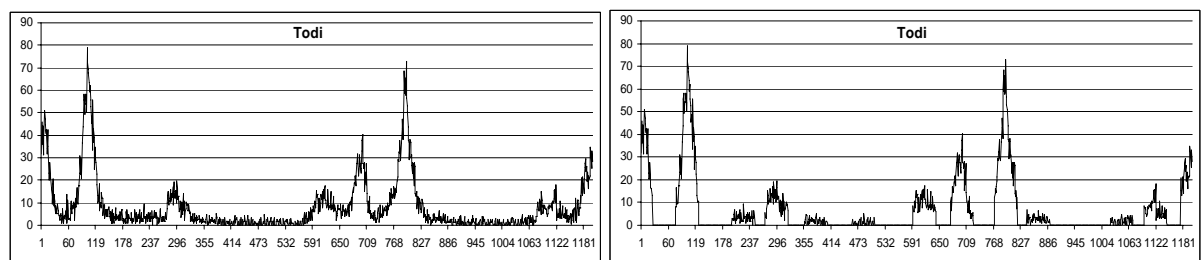

Figure 3 : Distribution of Mian-ki-Malhar.

Figure 4 : Distribution of Todi.

Each of the total 76 truncated versions of the distribution files contains 600 data points. Pair wise correlation of these data files were found by the help of in-house developed software

RESULTS

The tables below are self explanatory and show correlation values. Bold lettered entries show erroneous results.

Singer names are given as s1, s2, ….,s19. For correlation between signals of same raga (self correlation), values of 0.5 or more are considered to be good values (success). For correlation between signals of different raga (cross correlation), values of 0.5 or more are considered to be bad values (failure).

Left hand corner of each table contains two capital letter separated by a hyphen. The entry indicates the pair of raga concerned for the table. For the same raga (self correlation) the letters are same. The letters are first letters of the respective raga – Bhairav (B), Darbari Kannada (D), Mian-ki-Malhar (M) and Todi (T).

B-B	s1	s2	s3	s4	s5	s6	s7	s8	s9	s10	s11	s12	s13	s14	s15	s16	s17	s18
s2	0.6																	
s3	0.6	0.4																
s4	0.8	0.5	0.7															
s5	0.7	0.7	0.4	0.6														
s6	0.7	0.5	0.2	0.6	0.6													
s7	0.8	0.6	0.5	0.7	0.7	0.7												
s8	**0.5**	**0.4**	**0.3**	**0.4**	**0.4**	**0.3**	**0.4**											
s9	0.8	0.5	0.6	0.8	0.7	0.7	0.8	**0.4**										
s10	0.8	0.6	0.6	0.9	0.7	0.7	0.7	**0.4**	0.8									
s11	0.7	0.7	0.5	0.7	0.8	0.7	0.8	**0.5**	0.8	0.7								
s12	0.7	0.4	0.4	0.7	0.6	0.8	0.6	**0.3**	0.8	0.7	0.7							
s13	0.4	0.4	0	0.4	0.6	0.7	0.6	**0.2**	0.5	0.5	0.5	0.4						
s14	0.7	0.3	0.6	0.8	0.4	0.6	0.7	**0.3**	0.8	0.7	0.5	0.7	0.3					
s15	0.7	0.5	0.6	0.8	0.6	0.6	0.8	**0.4**	0.8	0.8	0.7	0.5	0.4	0.7				
s16	0.7	0.5	0.7	0.8	0.6	0.5	0.7	**0.4**	0.8	0.8	0.7	0.6	0.3	0.7	0.8			
s17	0.8	0.5	0.5	0.7	0.6	0.7	0.7	**0.3**	0.6	0.8	0.5	0.6	0.6	0.7	0.6	0.6		
s18	0.8	0.7	0.6	0.8	0.6	0.6	0.7	**0.5**	0.7	0.8	0.7	0.6	0.3	0.6	0.6	0.6	0.7	
s19	0.6	0.6	0.2	0.4	0.6	0.7	0.7	**0.2**	0.6	0.6	0.5	0.5	0.8	0.5	0.6	0.5	0.7	0.4

Self Correlation : Bhairav vs. Bhairav (80 % success). Singer s8 shows bad correlation values with other singers.

B-D	s1	s2	s3	s4	s5	s6	s7	s8	s9	s10	s11	s12	s13	s14	s15	s16	s17	s18	s19
s1	0.3																		
s2	0	0																	
s3	0.5	0.2	0.6																
s4	0.3	0.2	0.4	0.4															
s5	0	0	0.1	0.1	0														
s6	0.1	0	0.1	0.4	0.2	0.2													
s7	0.2	0.1	0.3	0.3	0.3	0.3	0.5												
s8	0.1	0	0.3	0.1	0.1	0.2	0.3	0.4											
s9	0.2	0.2	0.5	0.4	0.3	0.4	0.6	0.2	0.5										
s10	0.2	0.1	0.3	0.3	0.3	0.3	0.4	0.2	0.4	0.5									
s11	0	0.1	0.2	0.2	0.1	0.1	0.4	0.1	0.2	0.2	0.3								
s12	0.1	0.1	0.3	0.3	0.2	0.3	0.4	0.1	0.4	0.3	0.2	0.1							
s13	-0.1	0	-0.1	0.2	0	-0.1	0.1	-0.1	0	0	0.3	0	0						
s14	0.4	0.2	0.6	0.5	0.3	0.5	0.7	0.2	0.6	0.6	0.4	0.2	0.6	0.6					
s15	0.3	0.3	0.5	0.5	0.4	0.4	0.7	0.2	0.5	0.6	0.5	0.2	0.6	0.4	0.6				
s16	0.2	0.2	0.4	0.3	0.3	0.4	0.5	0.2	0.5	0.6	0.3	0.2	0.5	0.3	0.6	0.5			
s17	0.2	0	0.1	0.3	0.2	0.2	0.4	0.1	0.3	0.4	0.3	0.1	0.4	0.2	0.3	0.4	0.4		
s18	0.3	0	0.2	0.2	0.2	0.3	0.4	0.3	0.4	0.3	0.2	0.2	0.4	0.3	0.3	0.3	0.2	0.4	
s19	0	0	0.1	0.2	0.1	0	0.4	0	0	0.2	0.4	-0.1	0.1	0.2	0.2	0.3	0.2	0	0

Cross Correlation : Bhairav vs. Darbari (85% success)

B-M	s1	s2	s3	s4	s5	s6	s7	s8	s9	s10	s11	s12	s13	s14	s15	s16	s17	s18	s19
s1	0.1																		
s2	-0.2	-0.1																	
s3	0.4	0	0.5																
s4	0.3	0.1	0.2	0.6															
s5	-0.2	-0.1	-0.1	0	-0.1														
s6	0	0.2	0	0.1	0	0.2													
s7	0	0.2	0.1	0.3	0	0.3	0.4												
s8	0.1	-0.1	0.1	0.1	0	0	0.1	0											
s9	0.2	0.2	0.2	0.4	0	0.3	0.5	0	0.3										
s10	0.1	0.1	0.1	0.4	0	0.2	0.4	0	0.2	0.3									
s11	0	0	0	0.2	0	0	0.3	0	0.1	0.1	0.1								
s12	0.1	0.1	0.1	0.3	0	0.1	0.4	0.1	0.1	0.2	0.1	0.1							
s13	-0.3	0.1	-0.2	-0.1	0	0	0	-0.3	0	0	-0.1	-0.1	-0.1						
s14	0.3	0.2	0.4	0.5	0.1	0.4	0.6	0.1	0.3	0.5	0.3	0.3	0.1	0.4					
s15	0.2	0.2	0.3	0.5	0.1	0.3	0.6	0	0.4	0.5	0.2	0.2	0	0.3	0.4				
s16	0.3	0.2	0.4	0.5	0.1	0.3	0.6	0.1	0.4	0.5	0.3	0.3	0.1	0.3	0.6	0.7			
s17	0.1	0.2	0.1	0.3	0.1	0.3	0.3	0	0.2	0.2	0	0.2	0	0.1	0.3	0.4	0.3		
s18	0.1	0	0.1	0.3	-0.1	0.1	0.3	0.1	0	0.1	0	0.1	0.1	0.1	0.5	0.3	0.2	0.1	
s19	-0.3	0.1	-0.1	0	0.1	0.2	0.2	-0.3	0	0	0	0	0	-0.1	0	0.1	0	-0.1	0

Cross Correlation : Bhairav vs. Mian-ki-Malhar (92 % success)

B-T	s1	s2	s3	s4	s5	s6	s7	s8	s9	s10	s11	s12	s13	s14	s15	s16	s17	s18	s19
s1	0.6																		
s2	0.5	0.7																	
s3	0.7	0.5	0																
s4	0.6	0.4	0.1	0.6															
s5	0.3	0.5	0	0.5	0.3														
s6	0.2	0.1	0.2	0.2	0	0.1													
s7	0.4	0.4	0.2	0.4	0.1	0.4	0.5												
s8	0.4	0.3	0.3	0.4	0.2	0.3	0.4	0.4											
s9	0.4	0.3	0.1	0.6	0.2	0.5	0.6	0.4	0.6										
s10	0.4	0.5	0	0.5	0.1	0.5	0.6	0.2	0.6	0.6									
s11	0.4	0.5	0	0.5	0.3	0.4	0.5	0.2	0.5	0.5	0.4								
s12	0.4	0.2	0	0.4	0.1	0.3	0.4	0.3	0.4	0.4	0.3	0.3							
s13	-0.1	0	0.1	0	-0.1	0	0	-0.2	0	0	0	0	0						
s14	0.5	0.3	0.2	0.5	0.1	0.5	0.7	0.5	0.6	0.5	0.5	0.3	0.5	0.4					
s15	0.4	0.5	0.2	0.5	0.2	0.5	0.7	0.2	0.6	0.6	0.6	0.6	0.6	0.3	0.6				
s16	0.5	0.5	0.1	0.7	0.2	0.6	0.7	0.3	0.7	0.7	0.6	0.6	0.6	0.4	0.6	0.7			
s17	0.3	0.3	0.2	0.3	0	0.4	0.4	0.2	0.4	0.3	0.3	0.2	0.3	0.2	0.3	0.3	0.3		
s18	0.6	0.5	0.1	0.6	0.3	0.5	0.5	0.5	0.5	0.5	0.4	0.5	0.4	0.5	0.5	0.5	0.4	0.4	
s19	0.1	0.3	0.3	0.1	0.1	0.1	0.3	0	0.2	0.2	0.2	0.3	0.1	0.1	0.2	0.2	0	0.1	0.3

Cross Correlation : Bhairav vs. Todi (64% success)

D-D	s1	s2	s3	s4	s5	s6	s7	s8	s9	s10	s11	s12	s13	s14	s15	s16	s17	s18
s2	0.4																	
s3	0.5	0.2																
s4	0.6	0.6	0.4															
s5	0.7	0.6	0.4	0.8														
s6	0.7	0.6	0.6	0.7	0.8													
s7	0.6	0.4	0.7	0.8	0.7	0.7												
s8	**0.6**	**0.1**	**0.4**	**0.3**	**0.4**	**0.5**	**0.4**											
s9	0.7	0.5	0.6	0.7	0.7	0.9	0.7	**0.5**										
s10	0.7	0.5	0.6	0.7	0.8	0.8	0.8	**0.4**	0.8									
s11	0.5	0.5	0.4	0.7	0.7	0.6	0.8	**0.2**	0.6	0.7								
s12	0.6	0.6	0.3	0.5	0.7	0.7	0.4	**0.4**	0.7	0.6	0.4							
s13	0.7	0.5	0.7	0.7	0.8	0.9	0.8	**0.5**	0.9	0.9	0.7	0.7						
s14	0.4	0.2	0.7	0.6	0.6	0.7	0.8	**0.4**	0.7	0.6	0.5	0.4	0.7					
s15	0.6	0.5	0.7	0.7	0.7	0.8	0.8	**0.4**	0.9	0.8	0.7	0.5	0.9	0.8				

	s1	s2	s3	s4	s5	s6	s7	s8	s9	s10	s11	s12	s13	s14	s15	s16	s17	s18
s16	0.5	0.5	0.4	0.7	0.7	0.6	0.7	**0.3**	0.6	0.8	0.8	0.6	0.7	0.5	0.7			
s17	0.6	0.5	0.3	0.6	0.8	0.7	0.6	**0.3**	0.6	0.8	0.7	0.7	0.7	0.4	0.5	0.9		
s18	0.7	0.5	0.6	0.7	0.7	0.8	0.7	**0.5**	0.9	0.9	0.5	0.6	0.9	0.7	0.8	0.6	0.6	
s19	0.6	0.5	0.5	0.4	0.6	0.7	0.5	**0.3**	0.8	0.8	0.4	0.6	0.7	0.3	0.6	0.6	0.6	0.7

Self Correlation : Darbari vs. Darbari (82 % success). Same singer, s8, shows bad results.

D-M	s1	s2	s3	s4	s5	s6	s7	s8	s9	s10	s11	s12	s13	s14	s15	s16	s17	s18	s19
s1	0.5																		
s2	0.3	0.4																	
s3	0.4	0	0.5																
s4	0.3	0.5	0.1	0.3															
s5	0.5	0.5	0.2	0.5	0.1														
s6	0.6	0.3	0.4	0.6	0	0.3													
s7	0.3	0.4	0.3	0.4	0.2	0.4	0.7												
s8	0.4	0.1	0.3	0.3	0	0.1	0.3	0.3											
s9	0.6	0.4	0.5	0.7	0.1	0.4	0.6	0.4	0.5										
s10	0.5	0.4	0.4	0.7	0.2	0.4	0.6	0.2	0.4	0.6									
s11	0.2	0.5	0.2	0.2	0.3	0.4	0.5	0	0.3	0.5	0.3								
s12	0.4	0.3	0.1	0.4	0	0	0.1	0.3	0.1	0.3	0.1	0.3							
s13	0.6	0.4	0.4	0.7	0.1	0.4	0.6	0.3	0.4	0.6	0.4	0.4	0.3						
s14	0.4	0.2	0.3	0.3	0.1	0.3	0.5	0.1	0.3	0.5	0.4	0.2	0.3	0.4					
s15	0.5	0.4	0.4	0.5	0.1	0.4	0.6	0.2	0.5	0.7	0.5	0.4	0.2	0.5	0.5				
s16	0.3	0.5	0.2	0.4	0.2	0.4	0.4	0.1	0.3	0.5	0.2	0.4	0.2	0.2	0.1	0.7			
s17	0.3	0.4	0.2	0.4	0.1	0.3	0.3	0.1	0.2	0.4	0.1	0.4	0.2	0.2	0	0.5	0.6		
s18	0.7	0.4	0.6	0.8	0.2	0.4	0.7	0.3	0.5	0.7	0.5	0.6	0.2	0.6	0.6	0.8	0.6	0.6	
s19	0.6	0.3	0.5	0.7	0.1	0.3	0.5	0.3	0.3	0.5	0.3	0.4	0	0.5	0.4	0.7	0.5	0.5	0.5

Cross Correlation : Darbari vs. Mian-ki-Malhar (67% success)

D-T	s1	s2	s3	s4	s5	s6	s7	s8	s9	s10	s11	s12	s13	s14	s15	s16	s17	s18	s19
s1	0.5																		
s2	0.1	0																		
s3	0.5	0.3	0.2																	
s4	0.2	0.1	0.3	0.1																
s5	0.3	0.1	0.3	0.2	0															
s6	0.5	0.2	0.1	0.4	0.1	0.4													
s7	0.4	0.3	0.4	0.4	0.2	0.4	0.7												
s8	0.5	0.3	0.3	0.4	0.2	0.3	0.4	0.4											
s9	0.5	0.2	0.2	0.4	0	0.5	0.6	0.5	0.6										
s10	0.4	0.3	0.2	0.4	0	0.4	0.7	0.3	0.6	0.5									
s11	0.1	0.2	0.3	0.1	0.1	0.1	0.5	0.1	0.3	0.2	0.3								
s12	0.3	0.1	0	0.2	0	0.3	0.3	0.2	0.3	0.3	0.1	0.2							
s13	0.5	0.2	0.2	0.4	0	0.4	0.7	0.4	0.6	0.5	0.4	0.3	0.5						
s14	0.3	0.1	0.4	0.2	0.1	0.3	0.5	0.4	0.4	0.3	0.2	0.2	0.4	0.3					
s15	0.4	0	0.1	0.4	0	0.3	0.6	0.4	0.5	0.4	0.4	0.3	0.5	0.2	0.4				
s16	0.2	0.2	0.3	0.2	0	0.2	0.5	0.1	0.4	0.3	0.3	0.2	0.4	0.1	0.2	0.4			
s17	0.2	0.2	0.2	0.1	0	0.2	0.4	0.1	0.3	0.2	0.1	0.1	0.3	0.1	0	0.2	0.3		
s18	0.4	0.1	0.2	0.4	0	0.4	0.6	0.5	0.6	0.5	0.4	0.3	0.6	0.3	0.4	0.4	0.5	0.4	
s19	0.4	0.3	0	0.4	0	0.5	0.6	0.3	0.5	0.5	0.4	0.3	0.5	0.1	0.4	0.5	0.5	0.4	0.4

Cross Correlation : Darbari vs. Todi (81% success)

M-M	s1	s2	s3	s4	s5	s6	s7	s8	s9	s10	s11	s12	**s13**	s14	s15	s16	s17	s18
s2	0.5																	
s3	0.7	0.4																	
s4	0.7	0.5	0.7																
s5	0.5	0.6	0.6	0.3														
s6	0.6	0.6	0.7	0.4	0.8													
s7	0.6	0.5	0.8	0.7	0.6	0.8												
s8	0.5	0.2	0.5	0.5	0.2	0.2	0.3											

	s1	s2	s3	s4	s5	s6	s7	s8	s9	s10	s11	s12	s13	s14	s15	s16	s17	s18
s9	0.7	0.6	0.7	0.6	0.7	0.7	0.8	0.2										
s10	0.7	0.7	0.8	0.7	0.7	0.8	0.9	0.3	0.9									
s11	0.7	0.6	0.7	0.5	0.7	0.7	0.7	0.4	0.8	0.8								
s12	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.4	0.8	0.8	0.8							
s13	**0.3**	**0.1**	**0.2**	**0**	**0.1**	**0.3**	**0.2**	**0.2**	**0.2**	**0.3**	**0.2**	**0**						
s14	0.7	0.5	0.8	0.7	0.5	0.6	0.7	0.5	0.6	0.7	0.6	0.6	**0.1**					
s15	0.5	0	0.5	0.6	0.1	0.3	0.6	0.5	0.4	0.5	0.4	0.4	**0.1**	0.5				
s16	0.6	0.5	0.7	0.9	0.4	0.5	0.8	0.4	0.6	0.8	0.5	0.7	**0.1**	0.7	0.6			
s17	0.6	0.7	0.6	0.7	0.6	0.6	0.6	0.4	0.7	0.8	0.6	0.9	**0.2**	0.5	0.3	0.7		
s18	0.8	0.6	0.8	0.7	0.6	0.7	0.7	0.5	0.7	0.8	0.7	0.8	**0.2**	0.7	0.4	0.7	0.8	
s19	0.7	0.7	0.8	0.8	0.7	0.7	0.8	0.4	0.8	0.9	0.8	0.9	**0.1**	0.7	0.5	0.8	0.7	0.8

Self Correlation : Mian-ki-Malhar vs. Mian-ki-Malhar (76 % success). Singer s13 shows bad results.

M-T	s1	s2	s3	s4	s5	s6	s7	s8	s9	s10	s11	s12	s13	s14	**s15**	s16	s17	s18	s19
s1	0.2																		
s2	-0.1	-0.1																	
s3	0.2	0	0.2																
s4	0.4	0.1	0.1	0.4															
s5	-0.2	-0.1	0.3	-0.1	-0.2														
s6	0	0	0.3	0	0	0.1													
s7	0.3	0.2	0.3	0.4	0.1	0.4	0.6												
s8	0.3	0	0	0.2	0.1	0.1	0.2	0.4											
s9	0.1	0	0.2	0.2	0	0.2	0.3	0.2	0.3										
s10	0.2	0	0.3	0.2	0	0.2	0.5	0.3	0.3	0.3									
s11	0.1	0	0.2	0.1	0	0.1	0.3	0.3	0.2	0.1	0.2								
s12	0.1	0	0.3	0.1	-0.1	0.1	0.3	0.2	0.2	0.1	0.2	0							
s13	0.1	0	0	0.1	0.1	0	0.1	0.1	0	0	0	0	0						
s14	0.1	-0.1	0.1	0.1	-0.1	0.2	0.3	0.4	0.2	0.1	0.1	0	0.2	0					
s15	**0.8**	**0.5**	**0.1**	**0.8**	**0.5**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**	**0.6**	**0.7**	**0.7**				
s16	0.4	0.1	0.2	0.4	0	0.3	0.6	0.4	0.6	0.5	0.4	0.3	0.5	0.2	*0.4*	0.4			
s17	0.2	0.1	0.3	0.1	-0.1	0.1	0.3	0.2	0.3	0.2	0.2	0.1	0.2	0.1	*0.1*	0.1	0.4		
s18	0.2	0	0.3	0.1	-0.1	0.2	0.3	0.3	0.2	0.1	0.1	0	0.2	0.1	*0.2*	0.1	0.3	0.1	
s19	0.1	0	0.1	0.1	-0.1	0.1	0.3	0.3	0.2	0.2	0.2	0	0.3	0	*0.2*	0.1	0.3	0.2	0.1

Cross Correlation : Mian-ki-Malhar vs. Todi (90 % success). Singer s15 shows bad results.

T-T	s1	s2	**s3**	s4	s5	s6	s7	s8	s9	s10	s11	s12	s13	s14	s15	s16	s17	s18
s2	0.7																	
s3	**0.2**	**0.1**																
s4	0.9	0.8	**0.1**															
s5	0.7	0.8	**0**	0.7														
s6	0.8	0.8	**0.1**	0.8	0.6													
s7	0.8	0.7	**0.3**	0.8	0.5	0.8												
s8	0.7	0.4	**0.2**	0.6	0.4	0.6	0.6											
s9	0.8	0.7	**0.2**	0.9	0.5	0.8	0.9	0.6										
s10	0.8	0.8	**0**	0.9	0.6	0.9	0.9	0.5	0.9									
s11	0.7	0.8	**0.1**	0.9	0.7	0.7	0.8	0.5	0.9	0.8								
s12	0.7	0.8	**0.1**	0.8	0.7	0.8	0.8	0.4	0.8	0.9	0.8							
s13	0.8	0.7	**0.1**	0.8	0.6	0.7	0.9	0.6	0.9	0.9	0.9	0.7						
s14	0.8	0.7	**0.3**	0.8	0.7	0.6	0.7	0.6	0.7	0.7	0.7	0.6	0.7					
s15	0.8	0.7	**0.1**	0.9	0.7	0.8	0.8	0.7	0.8	0.8	0.8	0.8	0.8	0.8				
s16	0.8	0.8	**0.1**	0.9	0.6	0.8	0.9	0.5	0.9	0.9	0.9	0.8	0.9	0.7	0.8			
s17	0.8	0.7	**0.2**	0.8	0.5	0.8	0.8	0.5	0.9	0.8	0.8	0.7	0.8	0.7	0.7	0.8		
s18	0.7	0.7	**0**	0.8	0.7	0.8	0.8	0.6	0.8	0.9	0.8	0.8	0.8	0.6	0.8	0.9	0.8	
s19	0.8	0.8	**0.3**	0.8	0.6	0.8	0.9	0.6	0.9	0.9	0.8	0.8	0.8	0.7	0.8	0.8	0.7	0.8

Self Correlation : Todi vs. Todi (88 % success). Singer s3 shows bad results.

Summary of results is shown below.

% Success	Bhairav	Darbari Kannada	Mian-ki-Malhar	Todi
Bhairav	80			
Darbari Kannada	85	82		
Mian-ki-Malhar	92	67	76	
Todi	64	81	90	88

% Failure for self correlation	
B-B	20
D-D	18
M-M	24
T-T	12
Average	16

% Failure for cross correlation	
B-D	15
B-M	8
B-T	36
D-M	33
D-T	19
M-T	10
Average	20

CONCLUSION

The results show highly encouraging values. The modified procedure is of much improved importance compared to the previous method and results.

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