Analysing a Raga Based Bollywood Song: A Statistical Approach

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Introduction

Statistical musicology is a rapidly growing field of study that employs statistical and mathematical techniques, including simulation, to analyze various aspects of music such as musical performance theory and the theory of musical structure. This field has practical implications for music and can help us understand music better. As the world becomes increasingly digitized, statistics is expected to play an even more important role in music research. Beran [1] explores the relationship between statistics and music, highlighting how statistical techniques such as multivariate analysis, cluster analysis, discriminant analysis, multidimensional scaling, and principal component analysis can be used to analyze musical features.In this study, the Bollywood song Aaoge Jab is analyzed using statistical methods. The musical notes played on a keyboard are detected and hypothesis testing is performed to determine if the notes have fixed probabilities throughout the song or if they vary. The note duration and Inter Onset Interval (IOI) graphs are also analyzed. The song is divided into three phrases, and statistical parameterization is used to compare the melody and rhythm of each phrase. Aaoge Jab Tum is based on raga Tilak Kamod and taal Keharva, where raga refers to a melodic structure with fixed notes and a set of rules that convey a particular mood during performance, and taal refers to a cycle of beats [2].

Methodology

The music data used in this study is a time series, where each data point represents a fundamental frequency recorded at a specific moment in time. These frequencies are then used to determine the sequence of musical notes that were played in the song, along with the onset and departure of each note. To achieve this, the audio recording was first converted into fundamental frequency using Praat software. The range of fundamental frequencies and their corresponding musical notes in three octaves, namely lower, middle, and higher, were then used to identify the musical notes at various instances of time. If a frequency fell outside of the given ranges, the nearest interval was used to determine the corresponding musical note. Notes that occurred less than five times in a row were ignored as they were considered to be noise.

Experimental Result and Discussion

This section provides a detailed analysis of the song recording, focusing on note duration (as shown in Fig. 1), Inter Onset Interval (IOI), IOI graph (as shown in Fig. 2). These measures are used to determine if the song is in rhythm or not. Assessing rhythm involves measuring the periodicity in the musical piece, which is distinct from evaluating the song's pleasantness or aesthetic qualities.

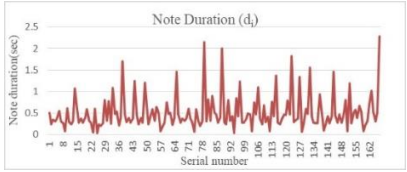

Figure 1: Note duration (in seconds) of the musical notes in the song recording

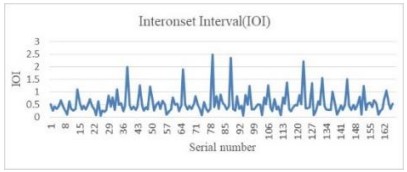

Figure 2: Inter Onset Interval (in seconds) of the musical notes in the song recording

The study also involves analyzing the unconditional probability, which is the likelihood of occurrence of each musical note, and the conditional probability, which is determined using a Transition Probability Matrix (TPM). The TPM matrix shows the probability of moving from one note to another, with the highest probability found in the transition from note C to note C. Furthermore, the distribution of musical notes is investigated using a chi-square goodness of fit test, which shows that they follow the multinomial model. The structural attributes of the music phrases in the song recording are also studied using a statistical parameterization approach, inspired by the work of Kostek [3].The melody and rhythm of each phrase in the song are described using five parameters, namely P1, P2, P3, P4, and P5, where P1, P2, and P3 represent melody and P4 and P5 represent rhythm. Melody is the "horizontal sonority of stationary states, notes, and microtones, embellished by various transitional movements, meends (gildes)" (Datta et. al. [4]) and rhythm measures the periodicity. These parameters from each phrase are combined to create Andrew's plot [5], a two-dimensional representation of a multidimensional point (as shown in Fig. 3), using a finite Fourier series equation: $f(t) = \frac{x_1}{\sqrt{2}} + x_2 \sin(t) + x_3 \cos(t) + x_4 \sin(2t) + x_5 \cos(2t) +$ ... ...

This equation helps to reduce the dimensionality of the study of melody and rhythm together without losing information on the original variables, the five dimensional point (P_1, P_2…P_5),

Table 1: Statistical parameters P1, P2, P3, P4 and P5 of the three phrases

	Phrase 1(0-33 seconds)	Phrase 2(33-67 seconds)	Phrase 3(67-92 seconds)
P1	245.578337	180.8840568	264.833181
P2	411.746522	369.146837	411.581312
P3	74.04705525	62.75650488	72.48876026
P4	1.71	2.15	2.28
P5	0.458923077	0.533448276	0.537727273

The melodic content remains fairly consistent between phrase 1 and 3 in comparison to phrase 2, while the rhythmic content shows similarities between phrase 2 and 3. Additionally, the value of P1 is highest in phrase 3, whereas P2 and P3 are highest in phrase 1 (Table 1).

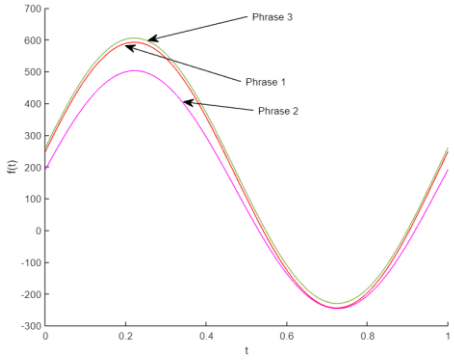

Figure 3: Andrews Plot showing combined melodic and rhythmic effect in 3 phrases of the song

Conclusion

Through a thorough analysis of the song recording, it has been determined that the musical notes conform to the multinomial model, and that the rhythm is frequently lost, as evidenced by the IOI graph. The longest note in the song is the final note, which is C and lasts 2.28 seconds, as shown in the note duration graph. The unconditional probability analysis indicates that the note most likely to occur is C, and the transition probability matrix demonstrates the dependence of one note on another.

The interaction between melody and rhythm is perceived when listening to a song, and Andrews plot enables a graphical assessment of this interaction. The statistical parameterization approach in Andrews Plot (Fig. 3) suggests that the combined melodic and rhythmic effect was highest in Phrase 3, followed by Phrase 1 and then Phrase 2.

References

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