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CAN THE TIME THEORY OF HINDUSTANI RAGAS BE DEMYSTIFIED SCIENTIFICALLY?

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Abstract:

The time theory in Hindustani ragas is controversial and debated among musicians and musicologists alike with at least three contrasting theories. The present note places on record the latest research that attempts to demystify it.

Key Words: Raga; Time Theory; Music Signal Processing

1. Introduction:

Datta et al. [1] have defined music as *an emotive, acoustical and cooperative communication, universal in nature* (observe the tactical usage of the word *universal* which separates music from speech). Indian classical music (ICM) has two broad components: North Indian or Hindustani and South Indian or Carnatic forms. In either form, the nucleus is the raga. A raga is *a melodic structure with fixed notes and a set of rules that characterize a particular mood which is conveyed through performance* [2].

Although the concept of time theory in Hindustani ragas is almost a century old, from the time of Bhatkhande [3]-[5], it is still an unexplored area as very few works have been carried out in this regard. The very reason behind this is that there are controversies with at least three different views of the aforesaid time theory. The first view holds that the time theory must be maintained strictly, the second contradictory view says that the time theory is illogical and need not be followed strictly. There is a third theory which says that every raga generates a particular emotion which can be connected to some particular time of the day. Thus, for example, *raga Bhairav* generates a feeling of waking up from sleep which may be related to morning. However, this third theory is not forcing the artist to perform *raga Bhairav* in the morning only [6] [7].

2. Our Contribution:

2.1 Pilot Study:

We had carried out the work where objectivity is being maintained as against the three views which have subjectivity concerned, where encouraging results were seen in one scientific study [8]. A part of this scientific study included the identification of the relevant features i.e time domain features (energy, zero crossing rate and entropy) where the audio samples were taken for four different rendition time (early morning, afternoon, evening and night).

2.2 Extension of the Pilot Study:

Although it was a pilot study where, only the time domain features were taken, in a recent work it has been successfully extended it to frequency domain features [9]. In this work, *Spectral Centroid and Zero Crossing Rate were found to be the two distinguishing statistical pairs whose correlation coefficient can be used to differentiate a morning raga and a night raga*. The argument defending this finding is that among all the feature pairs that have been considered for a morning raga; the correlation coefficient was found to be significant for the above two feature pairs only whereas when pairs of other features were taken, the correlation coefficient was found to be insignificant. For night ragas, all possible pairs are uncorrelated. Hence, it is concluded that only spectral centroid and zero-crossing rate, which depict the shape of the distribution with respect to spectral position and the rate of sign change respectively, and not other features can be used to distinguish between a day raga and a night raga.

2.3 Music Signal Processing and Time Theory of Ragas:

A signal processing approach was aimed at developing audio classification system based on Support Vector Machine (SVM). It classifies two audio classes of Indian songs namely a *raga bandish* and a *raga* based song. Previously, researchers have implemented classification techniques using Auto Associative Neural Network (AANN) model, Gaussian Mixture Model (GMM), Radial Basis Function (RBF) model etc. The classification accuracy with the above mentioned techniques is quite low. In our work, we have used Empirical Mode Decomposition (EMD) and extracted Temporal features, Spectral features and MFCC based features which show better classification accuracy. Our database comprises of 15 vocalists who rendered each category of songs making a total of 150 songs of each category, recorded in standard recording environment. The highest classification accuracy of 98.68 % was reported for two features namely: *entropy of energy* and *zero crossing rate*. Application of EMD in Indian music with high classification accuracy is a novelty [9]. An outline on EMD is provided in section 2.4. For further literature on EMD the reader is referred to [10].

2.4 Empirical Mode Decomposition:

There are certain class of mathematical functions that are based on their local properties, popularly known as intrinsic mode function (IMF) for which the instantaneous frequency can be defined everywhere. The necessary conditions to define a meaningful instantaneous frequency are that the functions are symmetric with respect to the local zero mean, and have the same numbers of zero crossings and extrema. IMF is a function that satisfies two conditions:

- in the whole data set, the number of extrema and the number of zero crossings must either equal or differ at most by one; and
- at any point, the mean value of the envelope defined by the local maxima and the envelope defined by the local minima is zero.

3. Experimental Findings:

For raga recording, a total of 15 vocalists comprising of 10 male vocalists and 5 female vocalists who were asked to render ten different ragas according to their choice. The raga recordings comprised of *bandish*, a song like composition in a raga maintaining the raga rules strictly. The same procedure was followed in the recordings for raga based songs, where the raga rules need not be maintained strictly rendered by not only the previous set of vocalists but three new ones too. Hence, our database comprises of 150 files each for two different classes of audio samples i.e, raga *bandishes* and raga based songs, abbreviated as RB and RS respectively in the block diagram as shown in Figure 1.

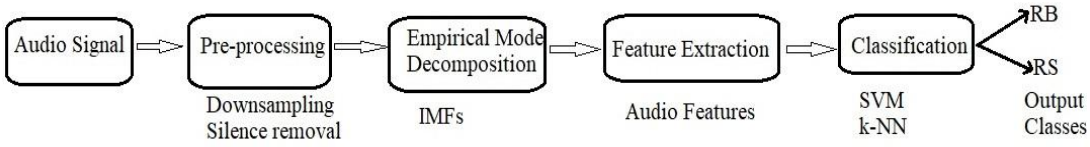

Figure 1: Block diagram of the proposed audio classification system

The classifier performance can be inspected more closely by plotting a Receiver Operating Characteristic (ROC) curve, which shows true positive rate versus false positive rate (equivalently, sensitivity versus 1–specificity) for different thresholds of the classifier output. One of the ROC curves are shown for classifier outputs after decomposition into IMFs respectively (Figure 2).

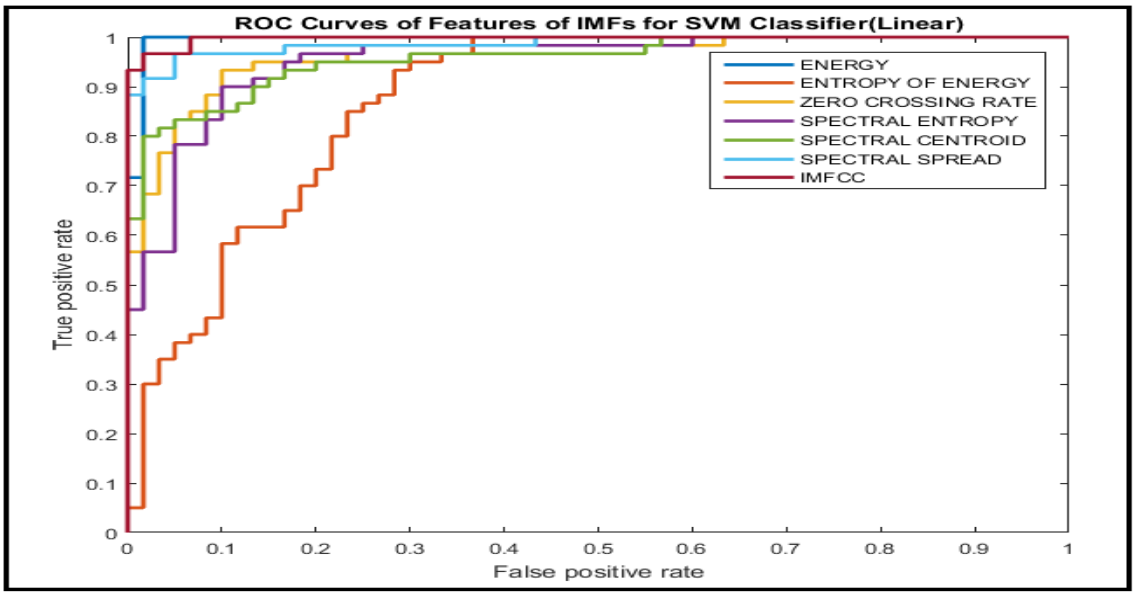

Figure 2: ROC curves of features of IMFs for SVM Classifier (Linear)

4. Concluding Remarks:

Although, relevance of time domain and frequency domain features for audio classification are satisfactory, one can use IMF based features for better classification accuracy as seen from the present work. Moreover, this work is limited to comparatively smaller database, but it can be further extended to classification into other genres of Indian music like ghazals, devotional songs, folk songs, etc.

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