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Rhythm Extraction from Expressive Body Movement Responses of North Indian Classical Music

Ram K. Nawasalkar   Dr.V.M. Thakre   Dr.Pradeep K. Butey

Abstract **:- For North Indian Classical Music, beats are detected to describe rhythm of music. In this proposed framework, a low dimensional functional model is set up that accounts the variability in the expressive body movement responses to North Indian Classical Music. With the functional principal component analysis, the modeled individual body movements as a linear combination of a group average and a number of eigenfunctions. Using a correlation matrix standardizes the data and makes reference to the group's mean movement for analysis of chest and hand movement. After that the rhythm information using rhythm of motion is extracted.**

Keywords **: Music beat, Tempo, rhythm of motion, musical expressiveness.**

I. INTRODUCTION

The influence of Classical music as a nonverbal expressive communication system is widely recognized. The nonverbal expression and communication of emotions, feelings, ideas, and intentions are considered in body movements. A successful and effective communication of musical expression requires that human expressive movement responses to North Indian Classical Music. Accordingly, we are able to define what is common in the expressive response of a population (commonality), as well as what is different in the expressive responses of the individuals of this population(individuality)[1].

While listening music, listener spontaneously taps their fingers or feet according to built-in ‘laya‘ (called as periodic structure) present in song. Sometimes people express his emotions or a meaning of music in the form of dancing. Listening of Classical Music is used either for stress release, entertainment or education purposes, through which experts elaborately produced or share his ample knowledge.

The concept “rhythm” describes patterns of changes in various disciplines. In music, *beat* refers to a perceived pulse marking off equal durational units [2], and on the basis we compare or measure rhythmic durations [2,3]. *Tempo* refers rate at which beats strike, and *meter* describes pronunciation structure on beats. Above parameters jointly determine how to recognize music rhythm. Focus on extracting *motion beats or rhythm* from expressive body movement, which play an essential role in constituting ROM. and interchangeably use “rhythm” and “beats” in this paper.

To extract implicit rhythm derived from human expressive body movement, need finer motion analysis. For the similar music rhythm, a different listener may squat, followed by twisting his body at the music beat strikes. Listeners have diverse moving patterns, but it can easily sense that they move according to the same music rhythm.

The grouping of several notes woven into a composition in a way, which is pleasant to the ear, is called a Raga. Each raga creates an environment, which is associated with feelings and sentiments.

The Raga is the foundation of classical music. It is based on the principle of a combination of notes selected from 22 note intervals of the octave. A performer with enough training and knowledge alone can create the desired emotions, through the arrangement of shrutis and notes.

The 7 swaras in different combinations give 10 thaats (groups). Thaats give birth to all the Ragas in North Indian Classical Music. The combinations of swaras for a raga must be aesthetically appealing [4].

II. AIM OF STUDY

The aim of this paper is to develop a dynamic approach to analyze how people mirror musical expression in their free and spontaneous body movement in response to Indian Classical Music.

The formulated goal imposes some challenges.

A. Music Is a Dynamic Phenomenon

A body movement synchronization to Indian classical music is a dynamic phenomenon, the method should allow for describing model parameters in terms of basic movement patterns extracted from real movements of participants, rather than in terms of single values that capture a particular feature of a particular movement segment. Such an approach has currently been explored by Leman and Naveda [12] and Fanet al. [13], who used periodicity analysis to capture the spatiotemporal representations of gestures. Their approach however, still requires a segmentation step using periodicity (beats) to determine segment boundaries. The newly proposed method avoids the cumbersome segmentation process and focuses directly on the process dynamics.

B. Different Body Parts Act Differently

In this study, the focus parts of the human body (such as the hands and chest) are better suited for capturing expressiveness. The human body can be displayed as a chain of rigid bodies connected at joints that provide a number of degrees of freedom (DOFs). Chest has limited DOFs and hands have many DOFs.

C. Movement Variability

There may be a significant degree of interindividual and intraindividual variability among peoples movements. It is possible to capture this aspect by extracting a shared model from the population. Starting from this model, rebuild the individual responses with some additional parameters that characterize each individual. The number of parameters required for rebuilding the individual expressive responses to Indian Classical Music defines the dimensionality of the expression space for the population. Consideration of the expression space is low-dimensional because populations would have more difficulties in mirroring the musical expression. To cope with the aforementioned challenges, it may develop a statistical method that captures the essential functional features of human expressive movements as a dynamic model [1].

III. Method

Listener may move forward and backward periodically, move in the same movement periodically, according to some implicit tempo[2]. Data are collected from the markers of the motion capture system, are converted to Cartesian coordinates referencing a fixed axis system with the origin located on a fixed spot on the floor[1].

Therefore, the calculation of the speed signal was handled in two steps. Firstly, the speed signal was calculated from the motion capture positional coordinates and secondly it was low pass filtered.

In first step, calculation of the speed signal, used a linear regression-based derivation filter with a regression window. The regression filters are used identical to first order Savitzky-Golay smoothing filters [5].

A. Participants

Distinct groups of participants were found on the basis of their musical background. In group musically trained as well as musically untrained participants was composed including male and female. A mean age of Subjects from the musically trained and untrained group has taken.

Moreover, how the familiar participants were with the type of *Raga*'s in North Indian Classical Music used in this experiment.

Participants were invited independently to take part in an experiment where their movements were recorded. The participants received the task of moving spontaneously to the classical music. This was formulated as: Translate your experience of the Indian classical music into free full-body movement. Try to become absorbed by the classical music that is presented and express your feelings into body movement. There is no good or wrong way of doing it[1]. Moreover, ready the room needs completely dark, as the pilot study had indicated that, this made the participants more comfortable and less constrained to execute this task.

B. Musical Stimulus

The musical stimulus is based on the *'Thaat'*. There are different Raag's has to be taken from *Thaat*. First 5 - 10 min musical piece is characterized by passages that articulate extreme contrasts in physical acoustic energy, reflecting two contrasting expressions, namely, a Heroic and Lyric expression.

The differences between the Heroic and Lyric passages were checked on the basis of a (psycho-)acoustical analysis. The properties that were extracted from the audio signal encompassed an energy property (i.e., amplitude), a rhythm property(i.e., onset likelihood), and spectrum properties (i.e., irregularity, spectral flatness, spectral kurtosis, spectral sharpness, spectral variance)[1,6].

Analysis of Methodology

Music psychology pioneer Carl Seashore [1,7] introduced the idea that expressive performance consists of deviation from the regular in sound properties such as loudness, tempo, articulation and intonation. Davidson [8] enhances the idea of embodiment to it, and mentions that each movement type (for instance, the wiggle) can be executed in various ways giving the potential for a range of expressivity levels to be elicited.

On the other hand, the terms deviation and regular may have negative connotations. Regular stands for normal behavior and deviation for abnormal behavior. This is the connotation want to avoid. Association between music invoked body movement and abnormal behavior do not want. Hence, use of terms variation and reference instead.

A. Motor-Mimesis of Musical Tempo

The investigation of periodicity of expressive movement responses to '*Raga*', equals or differs from the tempo of particular *Raga*. This tempo is calculated from manually annotated inter beat time intervals for the different musical style (means different gharana style) fragments. To analyze periodicity in the body movement, the dominant frequencies are extracted by means of Fourier analysis.

1) *Manual Analysis of Musical Signal:*

The beat times of the musical piece were manually annotated using Audacity-software [1,9]. From the explanation, the inter beat time intervals slightly fluctuate during the *Raga* piece.

2) *Fourier Analysis of Speed Signal:*

As the tempo differ from style fragment to style fragment, not to apply a Fourier analysis on the entire time interval of the speed movement signal, but on manual segmentation in line with the style fragments.

The Fourier analysis is done on musically trained and untrained subjects. Firstly, analyze every independent subject (and every marker) and secondly merge these results to end with one spectrum per group. The merging process consists out of a normalization step followed by an averaging step. The normalization step is required to compensate for subjects performing at different speed levels.

Motor-Mimesis of Syntax and Semantics in Music

After that, for hypothesis testing, start to analyze musically trained and untrained persons. Using a correlation matrix standardizes the data and makes reference to the group's mean movement.

1) Analysis of Chest Movement:

For musically trained and untrained persons, the correlation matrix PC for chest is displayed a density plot. This density plot is a low resolution version (this because of displaying and printing reasons). The intervals of coherence stand for high correlations between levels of expressiveness in a group at every two distinct time stamps in a continuous time interval. The borders of these intervals can be determined by a user customized heuristic.(Ex. Heuristics that requires a percentage of correlation coefficients to exceed a predefined threshold.)

2) Analysis of Dominant Hand Movement:

As mentioned before, hand movement is analyzed against a new axis system, eliminating all influences of the torso (III Method).

Correlations for the dominant hand disclose different patterns compared to chest consequently suggest motor-imitation of other structural elements in the music (e.g., changes in musical style).

Modeling Expressiveness

Among these musically trained and non-trained participants, modeling process is applied for musically trained group. The process is equal for the musically non-trained participants but is not discussed. In addition, the boundary of that discussion is models for chest and dominant hand. For both (chest and dominant hand), use log of the speed envelope signal as a input signal. The modeling process is based upon functional principal component analysis (FPCA).This FPCA uses the correlation matrix as input[1].

Body movement sampled gives results in an equivalent multivariate data set. The benefit of a multivariate approach is that algorithms like PCA can be applied directly but this is computationally difficult. So, implement a functional data analysis (FDA) approach, is based on one additional assumption, having a relationship between values that are only a few samples apart. For this requirement decomposing our data set in a set of basis functions and that reduces the dimensionality of the problem.

The basis functions are determined out of a cross-validation exercise where we calculate the error [Mean Squared Error (MSE)] between model and signal for a different number of basis functions. This situation is valid for chest and dominant hand.

FPCA calculates a set of eigenfunctions using least square algorithm. In addition, place a penalty on the second derivative of the eigenfunctions to favor smooth functions. In this way, follow the method as outlined by Ramsay [10].

Rhythm of Motion

Different Listeners may have different interpretations for the same *'Raga'* in North Indian Classical Music, and they may not completely move with rhythm of Same *'Raga'*. Fortunately, most Listeners have common consensus about how and when to move their bodies.

i) Motion Beat Candidate Detection

Based on the extracted expressive body movement, detect participant motion beats for Rhythm of Motion (ROM) extraction.

A stop action is often a joint of movements. A participant may move his hand toward some direction according to '*laya*', stop when a music beat strikes, and later move. The stop action represents the movement has completely ended or just a temporary stop which serves a start of another movement. To detect stop of a motion using the motion magnitude, and detect local minimums of the magnitude history based on a modified hill climbing algorithm. Finally, the set of local minimums are seen as motion beat candidates[2].

ii) Rhythm Estimation and Filtering

In this section, the scheme proposed in [11] for motion beat refinement and dominant period estimation is used. Note that not every detected movement or stop point is truly a motion beat. So, the scheme first finds the dominant period from motion beat candidates, and accordingly estimates the reference beats. Using reference beats, to estimate actual motion by finding the candidate beats that have small temporal differences to reference beats.

For prediction of dominant period from motion beat or motion beat sequence derived from single movement different methods are present and from which estimate the reference beats with multiple movements[2].

IV. Conclusion and Future Work

In this proposed framework, rhythm extraction is done from expressive body movement. For that firstly start analyzed group of participants expressively move, spontaneously and individually to Indian Classical Music. In this group participants had received formal musical education and some are not having a musical education.

It concludes that the musically untrained group focuses on torso movement expressing the tempo of the music and the musically trained group focuses on the dominant hand expressing additional structural elements such as musical amplitude. Ultimately, these models could also be directly applicable to examine group movement in a diverse set of human activities. From this diverse set rhythm of motion extracted. This approach well captures finer human movement, especially periodic movement changes in responses to North Indian classical Music. Music is transformed into motion beat and music beat sequences, and is accordingly compared.

In future apply above framework implemented during different Taal in classical music. It is also capable of interpreting musical syntax and semantics in their movement responses to North Indian Classical Music, using different body parts of participants.

V. References

[1] Denis Amelynck, Pieter-Jan Maes, Jean Pierre Martens and Marc Leman, "Expressive Body Movement Responses to Music Are Coherent, Consistent, and Low Dimensional", Digital Object Identifier 10.1109/TCYB.2014.2305998, IEEE TRANSACTIONS ON CYBERNETICS, January 29, 2014.

[2] Wei-Ta Chu and Shang-Yin Tsai, "Rhythm of Motion Extraction and Rhythm-Based Cross-Media Alignment for Dance Videos", IEEE TRANSACTIONS ON MULTIMEDIA, VOL. 14, NO. 1, FEBRUARY 2012.

[3] R. Gauldin, "Harmonic Practice in Tonal Music", 2nd ed. New York: Norton, 2004.

[4] http://www.vallabhkankroli.org/kirtan%20dhol%20pad_rich%20heritage_chapter_1.htm#_Toc152296 347.

[5] A. Savitzky and M. J. Golay, "Smoothing and differentiation of data by simplified least squares procedures."Anal.Chem., vol. 36, no. 8,pp. 1627–1639, 1964.

[6] P. J. Maes, E. Van Dyck, M. Lesaffre, P. Kroonenberg, and M. Leman, "A dimensional model for the study of the coupling of action and perception in musical meaning formation: A case study with Brahms", First Piano Concerto," Music Perception, in press.

[7] Carl E. Seashore, "The Psychology of Music", New York, NY, USA:McGraw-Hill, 1938.

[8] J. Davidson, "Qualitative insights into the use of expressive body movement in solo piano performance: A case study approach", Psychol. Music, vol. 35, no. 3, pp. 381–401, Jul. 2007.

[9] D. Mazzoni and R. Dannenberg, "Audacity [software]", The Audacity Team, Pittsburg, PA, USA, 2000.

[10] J. Ramsay, "Functional Data Analysis", Wiley Online Lib., 111 River Street Hoboken NJ07030-5774 USA, 2006.

[11] I. Laptev, S. J. Belongie, P. Perez, and J. Wills, "Periodic motion detection and segmentation via approximate sequence alignment", in Proc. Int. Conf. Computer Vision, 2005.
[12] M. Leman and L. Naveda, "Basic gestures as spatiotemporal reference frames for repetitive dance/music patterns in samba and charleston", Music Perception, vol. 28, no. 1, pp. 71–91, Sep. 2010.
[13] R. Fan, S. Xu, and W. Geng, "Example-based automatic music-driven conventional dance motion synthesis", IEEE Trans. Vis.Comput. Graph., vol. 18, no. 3, pp. 501–515, Mar. 2012