World Academy of Science, Engineering and Technology
International Journal of Cognitive and Language Sciences
Vol:18, No:5, 2024

Cognition Technique for Developing a World Music

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Abstract**—**In today's globalized world, it is necessary to develop a form of music that is able to evoke equal emotional responses among people from diverse cultural backgrounds. Indigenous cultures throughout history have developed their own music cognition, specifically in terms of the connections between music and mood. With the advancements in artificial intelligence technologies, it has become possible to analyze and categorize music features such as timbre, harmony, melody, and rhythm, and relate them to the resulting mood effects experienced by listeners. This paper presents a model that utilizes a screenshot translator to convert music from different origins into waveforms, which are then analyzed using machine learning and information retrieval techniques. By connecting these waveforms with Thayer's matrix of moods, a mood classifier has been developed using fuzzy logic algorithms to determine the emotional impact of different types of music on listeners from various cultures.

Keywords**—**Cognition, world music, artificial intelligence, Thayer's matrix.

I. Introduction

A. Cross Cultural Music Cognition

CROSS cultural cognition of music is an attractive trend today. Jacoby et al. [1] have described the issues involved in cross cultural cognition of music. In order to obtain a truer insight, they have recommended participation of people from different cultural backgrounds to work together and develop adequate strategies for overcoming the differences. People need to come together and develop a common understanding of the ethical, methodological, and denominational differences.

B. Music Cognition Evolution

Cross et al. [2] have raised the question of the different ways music effects differently in different cultures, that poses serious problems in discretely identifying the biological basis of musicality. One piece of music that has drastic effect on people of one culture, may have minimal effect on people of a different culture. Like speech, a certain music and its effect on people, as the authors have suggested, need to be studied in the context of it being a mixture of a biological component and a social component. These components, however are not easily distinguishable nor relatable. The authors have presented a survey of different efforts that have been made to trace the appeal to certain music in the evolutionary process of a certain culture.

C. Cross Cultural Music-Mood Differences and Similarities

Lee et al. [3] have reported a study of Korean and Chinese response to certain music. The two groups have centuries long history of interactions. Since the world wars, the south Koreans have been more exposed to western music while main land Chinese have lived in isolation, until recently. The authors have examined how differently similarly, these two groups respond to music today. In their view, such studies will help in bringing an inter-cultural universal music response system. The study has compared, a music to mood relationship, in the three cultures; American, Korean and Chinese, of particular music genres. A judgement parameter named intra-cultural agreement ratio has been proposed.

D. Indian and Western Music Comparison

Agarwal et al. [4] have compared the Indian and Western music forms. While not much systematic analysis of Indian music, in terms of genre, classification, rhythm, harmonics, timbre etc. is available, contrary to the western music, some work has been performed by the authors using spectroscopic analytical tools, and then AdaBoost classification and GMM modeling have been applied. They have reported that music forms that work well in western cultures may not necessarily work in the Indian environment. They have proposed to use translators for better results.

E. Three Planes of Music Analysis

Conti [5] has suggested three planes on which music analysis should be performed: Visual structure, acoustic space, and punch lining. Firstly, the structure of a song form can be displayed visually by modern technological methods. This is called 'diataxis'. Secondly, a certain song form needs to be judged in its acoustic space. Thirdly, punch lining, which means discovering a piece that represents a whole, and analyzing it. This is called 'synecdoche'. These are the three levels, analysis on which can help to distinguish differences and similarities of music of different cultures. These analyses include 'semiotics' which is relating certain music form with naturally occurring sounds, by the use of flags, logos, emoticons, signs and signals.

F. Automated Music Classification Attempts

Silla et al. [6] have presented an automated computer-generated method of music classification. In this method, a music piece is analyzed by a software in terms of binary units of space and time, to label the music piece in certain classification with which it falls. The algorithms used in this pursuit is naïve Bayes. It uses a decision tree neural network and compares the particular input to a date base already fed in to the machine. The authors are of the view that their proposed method produces better results than those obtained from conventional classifiers.

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II. Music across the World

A. Moving towards Global Culture

Hesser [7] visualizes that the information technology has given such a leverage to music that it has become an effective means to bringing people from all over the world together. This leverage has been fully used on over 100 projects in over 50 countries. Music has been used as a tool for mental and physical health, for trauma rehabilitation, for education and training at all ages, and for world peace. The projects have been found very cost effective, but highly performance oriented. Music has been found as having a strong impact.

B. Effectiveness of Music Compared to Language

Bontrager [8] describes the great effort the Disney group has exerted by bridging across 30 languages of the world by music, dubbing in local genre supported by animations. Their target of setting up of the right mood among their customers of all ages has been more than achieved. The message goes across well specially when the sound box is in the local environment. Of course, there have been problems on the way, such as poorly understood carryover to local translators, engagement and training of foreign personnel, dubbing of American movies in local styles, the gap between sounds and the sense they generate. The translators and interpreters have had an uphill task. Music adaptation in local tunes has been a difficult task. The music they choose could gain local popularity only when the original music composers and song writers understand the resulting mood response of the local audience.

C. Sensitizing Song Writers and Music Composers on Needs of the Global Audience

Kubacki and Croft [9] have identified a number of global stakeholders, who are interested in such a music which has appeal, across cultures, borders and economies. Top of the list are global businesses who want to promote their sales. Then come the non-profit organizations, who have international missions and roles to play. There are TV and radio channels who have audiences the world over. There are musicians and artists who want to project themselves internationally. The authors have also identified the supply chain partners, who are the original music creators, brand promotors, market developers, and distribution channels. The authors have also pointed out that the hurdles on the way are the attitudes of the musicians themselves. The musicians take their work as art rather than business. The authors have also suggested the way forward in terms of highlighting the value of unifying music of various sorts, providing full support of information technology and artificial intelligence. and offering better terms to musicians who take up international roles.

III. Cognition Technique for Music Classification

A. Classification Algorithms

Vatolkin and Theimer [10] have presented algorithms that are available in the name of music information retrieval (MIR) system. The MIR system works on digital audio signals, and stores them as a data bank. It then sets up a matrix, placing the data into categories. The categories typically are: melody, harmony, rhythm, timbre, and time scale. The algorithm can be built on a package such as MATLAB. From a given music piece, a dominant feature is taken up and labeled as temporal physical, harmonic or cultural. Classification is done according to (i) features, (ii) pruners, and (iii) classifiers. Some other packages that are used for classification are: jAudio, M2K, MusicMiner, and RapidMiner.

B. Advanced Classification Algorithms

Haggblade et al. [11] have suggested some advanced algorithms, such as: k-nearest neighbor, k-means, multi-class, and neural networks. They classify a music piece into: classical, jazz, metal, or pop. A Mel Frequency Cepstral Coefficients (MFCC) method is applied for this purpose. The input is mapped images of a song, whose classification is desired. This piece of information is fed and is matched around an existing database. Distance between two songs is measured by Fourier Mellin Transforms around k-means, and k-NN, and divergence is measured through the Kullback Leibler equation, where p(x) and q(x) are two multivariate Gaussian distributions with mean and covariance. Thus, the distance between the two clusters is measured.

The findings are cross checked by reporting of the general listeners. A typical algorithm is shown on Fig. 1 (a).

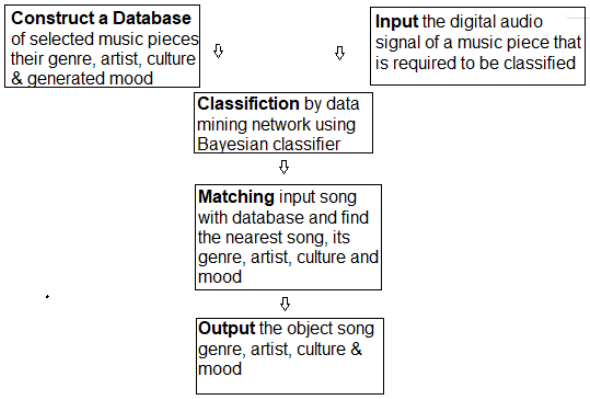

Fig. 1 (a) Music Classification Algorithm Flow Chart

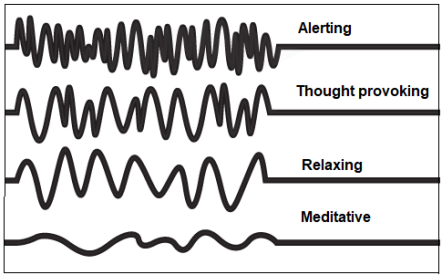

Fig. 1 (b) Shadow Following in Brain

C. Music Pattern Recognition in Our Brain

Patterson [12] describes how music pattern recognition goes on in our brain (Figs. 1 (b) and 2). According to him, the following four characteristics are searched and matched what is stored there:

- Tempo & Rhythm (taken as comforting; cautious, or turbulent);
- Pitch (taken as soft, pleasing, trouble-less, joyous, or serious, sorrowful, jubilant, mindful);
- Melody (taken as sorrowful or joyful); and
- Harmony (taken as curious or serious).

Upon every arrival of music signal in our brain, the brain starts to search in its own memory, if there is anything parallel or similar. There is a shadow following that goes on. If resonance is found, a mood of comfort and familiarity is induced. If any unknown pattern is noticed, fear, curiosity and discomfort are given in results.

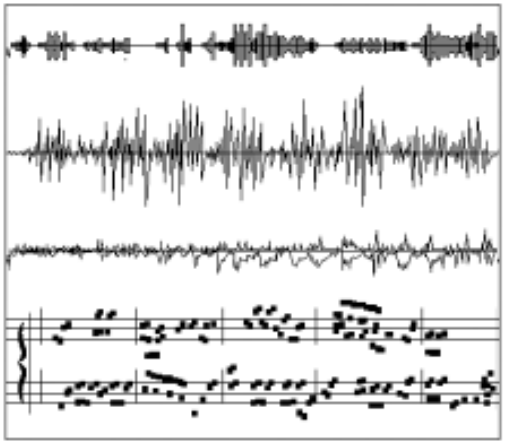

Fig. 2 Recognition of Patterns in Brain

Music signals generate pictures, patterns, and figures which are dynamic moving dancing and revolving. They induce certain moods, reactions and responses. These impressions sometimes are so subtle that they pass on genetically from generation to generation. This is where cultural attachment occurs to certain music. They become stronger and stronger in communities which live in isolation. But when different cultures mix with each other, new patterns, new sense impressions and new music to mood associations develop. When the mixing of cultures continually prolongs, the individual isolated patterns fade away, and in their place, the new patterns get indented.

D. Computational Modeling of Music to Mood Relationships

Lauriel [13] and Padial [14] have attempted to develop computational models by which an input piece of music can be interpreted in to a machine language, that can be matched with already existing store house of machine language versions of commonly known songs, whose generated moods are already recorded through public surveys and interviews. There is a huge library of stored data, that are gathered from these surveys and interviews, in terms of music songs on one side and the moods thus generated on the other side. An algorithm is used which reads an audio signal and turns into either a text signal, or a graphical signal. The machine goes out searching for the signals stored in the data bank, where attached to these signals, the information of resultant moods, obtained from surveys and interviews is stored. Any matching of the input signal with already stored signal gives a clue to the mood that the input signal is expected to generate.

IV. Translation in Music

A. Song to Song Translation

Franzon [15] has touched a novel idea of translating a song from one culture to another culture, such that it is singable, and it produces the same effect in the culture as the original culture. Three cultures have been selected: English, Swedish and Finish. Attempts have been made on the inter-changeability of their songs. Expert translators have been engaged. The check points given to them to take care have been: pitch, poetic content, musical effect, looking natural, phonetics, verbal coherence, energy, and singabilty. Algorithms need to be made to measure conformity of these check points, so that the efforts made on the songs can be verified.

B. Problems Being Faced in Translating Music from One Culture to Another

Susam-Sarajeva [16] realizes the importance of translation of music from one culture to another, yet it has been observed that enough considerations are not being given. The reasons for this non-importance have been investigated. Steps have been suggested to be taken to bring the subject to limelight. It has been suggested that a well thought of campaign should be taken up, both at the lowest artists level, and at the promoter's level.

C. Project Experiences in Music Translation

Desblache [17] has reported the experiences on an internationally sponsored project on translation of music from one culture to another. The considerations in this effort have been: text transfer, genre transfer, audience focus, and the target platforms to be engaged for this purpose. One such platform is opera houses, who are eager in this aspect. The project has involved international networks, inter-cultural platforms and art groups.

D. Music Translator Apps

Kucharovic [18] has described experiences of an App that is available for this purpose. A screen shot of the App is shown in Fig. 3 (a). When a music is played on the App, the sound tones and chords are saved in the form of musical notation. When another music is played and its musical notation is matched with one of the saved ones, a rating of conformity is reported.

V. Mood Classification

A. Chords Based Binary Music Mood Classification

Padial and Goe [14] have built an algorithm which takes in chords and modes of a song. It stores information on a binary database system. The information is analyzed to report: rhythm, mode, notes, pace, and harmonics. These data are correlated with a stored data, and thus mood, joyfulness, softness, annoyance, anguish, and vigor. The analysis has been extended to a broad range of cultures, artists, and music varieties. The authors have expressed that for this purpose, huge storage size and speed of computers is required.

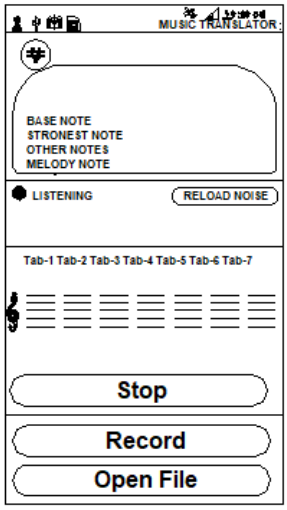

Fig. 3 (a) Screen Shot Music Translator App

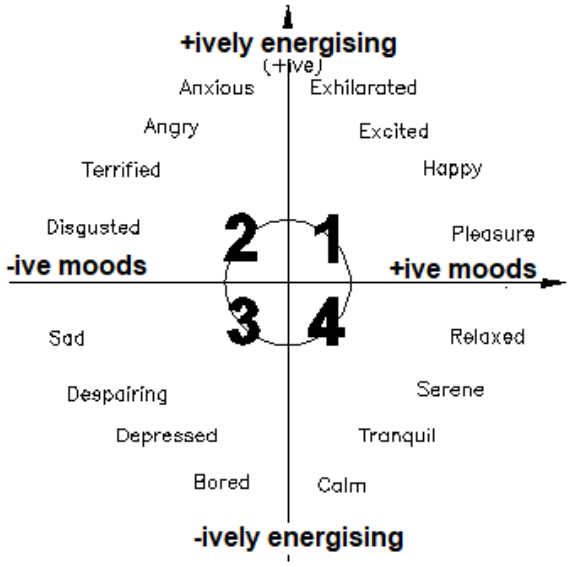

Fig. 3 (b) Thayer's Model of Mood

B. Sequence of Steps for Music Mood Relationship

Liu et al. [19] have described Thayer's model of mood in classifying moods generated by a music piece, by a 4-quadrant 2-dimensional emotional space. This is illustrated in Fig. 3 (b). A particular state of mood is defined by a 2x1 position vector. Positive Y direction represents positive emotional energy, and positive X direction represents positive emotions.

The flow chart describing the logic that has been used to find the relationship of a certain object song in terms of the mood it generates is illustrated in Fig. 4. Firstly, a data base is generated. A number of songs are selected which are stored in digital form in terms of their parameters. A survey is conducted to record the public opinion of the same songs in terms of the moods they generated. The moods generated by same songs are recorded in a 2x1 coordinate system on Thayer's model. This creates the reference database. The object song whose mood is needed to be predicted is input into the system in digital form in terms of its parameters. The Bayesian data mining algorithm is used to take the object song and match with the songs in the database. The song in the database that is nearest to the object song is noted and its mood set is printed out.

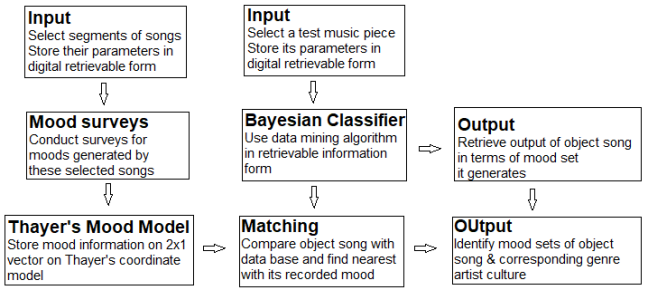

Fig. 4 Music Mood Relationship Logic

C. Music - Emotions Study in Non-Western World

Thompson and Balkwill [20] have stated that because of the non-existence of any tonal decoding system in music in the non-western world, it is difficult to analyze the music to emotions relationship in an analytical way; while it is easy in the western world. The authors have suggested that it is imperative that a music-emotion decoding system be developed. Only then, it could be possible to build a cross cultural transformation bridge.

D. Music to Mood Relationship in the Domain of Indian Popular Music

M. Ujlambkar [21] has claimed that with the data-mining and machine technologies that are available today, it is possible to analyze the music to mood relationship on Indian music as well. A number of popular Indian songs have been picked up for this purpose. Selected songs have been translated into digital ingredients such as tone, base, harmonics. With the use of a database of known music to mood ties, and a comparative algorithm, the moods and emotions that can possibly be induced from any object songs can be predicted. The same process can be applied to selected western musical pieces and their effect on Indian audience can be forecast.

E. Arabic Music Mood Relationship

Racy [22] explains that in Arabic music, a segment named Maqam occurs, which is unique in nature, such that it is a combination of eight tones and modulations. In it, the notes do not appear in simple frequency ratios. These are difficult to bring in writing form. The Maqams repeat in pieces called Ajnas. Those Ajnas which are closest to western notations, are shown in Fig. 5. Each Ajnas induces certain intense emotions. It is a hard task for western musicians to play anything similar to Ajnas, and produce that kind of emotions in Arabic audience.

F. American, Korean and Chinese

Lee and Hu [23], as mentioned earlier, have used a musical information retrieval system, and playing the same music piece, have observed the mood effects to American, Korean and Chinese audiences. The same piece created different effects in different cultures. Their work illustrates the issue that cross-culture music composers have to face.

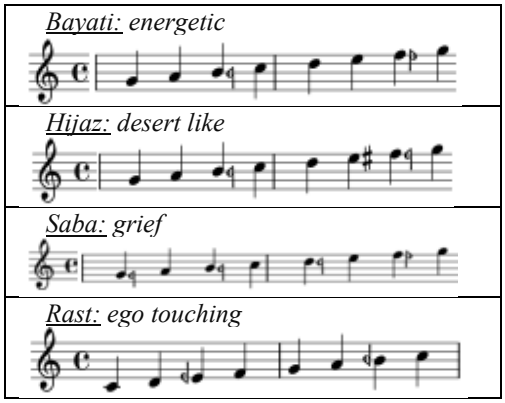

Fig. 5 Typical Ajnas and the Effect Produced

G. Umm e Kalthum in Musical Notations

Hong [24] has tried writing Umm e Kalthum songs in western notation, see Fig. 6. Then going on reverse, from notation back to song, serious lapses have been observed. This attempt suggests that the use of artificial intelligence, colossal data mining technique and advanced algorithms are needed to bridge this gap.

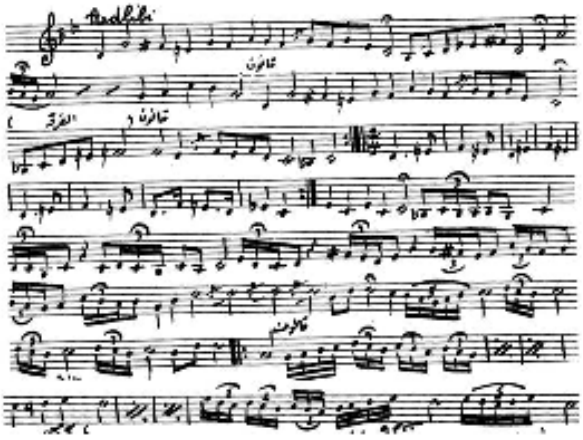

Fig. 6 Umm e Kalthum on Western Notation

VI. Cognition Technique Applied for Music of Global Standing

A. Most Viewed Korean Song that Goes Across Cultures

Wikipedia [25] produces a list of most viewed songs. Top most among them can be studied. Top viewed songs are so because they have a power of going across cultures. These are translated to standard notation sheets offered by Jared Anderson [26] such that the analysis of their basic ingredients can be made, and their rating on Thayer's mood model can be obtained.

The Baby Shark Dance is the first video that has reached over 13 billion viewers all across 64 countries, first appearing on YouTube in 2016, by a South Korean company. A piece from Baby Shark Dance in music sheet form is shown in Fig. 7. When analyzed on music parameters, it is revealed that the popularity, especially among the children, is on account of its up-beat, fun tone, and engaging melody. When projected on Thayer's mood scale, its popularity seems to be due to relieving the listener's fearful perception of sharks, to comforting fun.

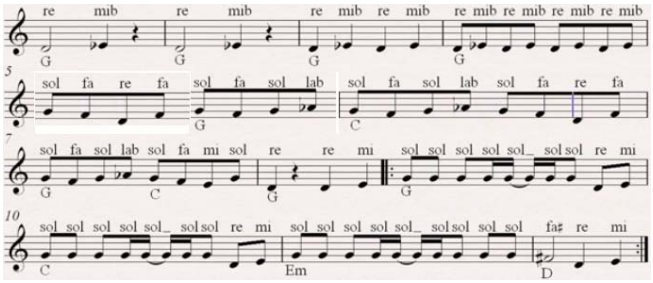

Fig. 7 Baby Shark Dance Translated onto Music Sheet

B. Most Viewed Arabic Songs Across Cultures

World Chart [27] discloses that Fi Haqat (I love You), sung by a Lebanese pop singer Nancy Ajram, hit the 20 million mark of viewers across cultures on YouTube. Her song translated on music sheet is shown in Fig. 8. On musical parameters, Fi Haqat is contemporary R&B (combining rhythm and blues with elements of pop), techno (electronic dance) and of varying tempo.

On Thayer's mood model, Fi Haqat shows absolute craziness, soul, funk and hip hop, and exotic. These are the characteristics that make music go across cultures.

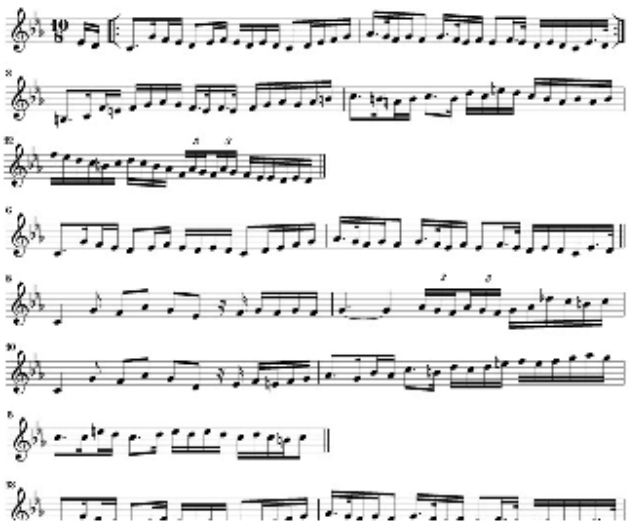

Fig. 8 Nancy Ajram Music Sheet

C. Most Watched Indian Songs Across Cultures

Singh [28] has shown that the song 'Jhoome Jo Pathaan', featuring Shah Rukh Khan and Deepika Padukone, composed by Vishal & Sheykhar, with vocals by Arijit Singh, Sukriti, and lyrics by Kumaar, has become the most viewed Indian song surpassing 650 m views on YouTube in 2022. The musical notation for the song is illustrated in Fig. 9. In terms of musical parameters, the song is upbeat, a dance track, and a modern fusion qawaali.

On Thayer's mood model, the song takes the audience to scenic environment, conveying the distinctiveness of Pathaans, and evoking a sense of intimidation, combined with a super-spy

feel. These characteristics contribute to making the music transcendent across cultures.

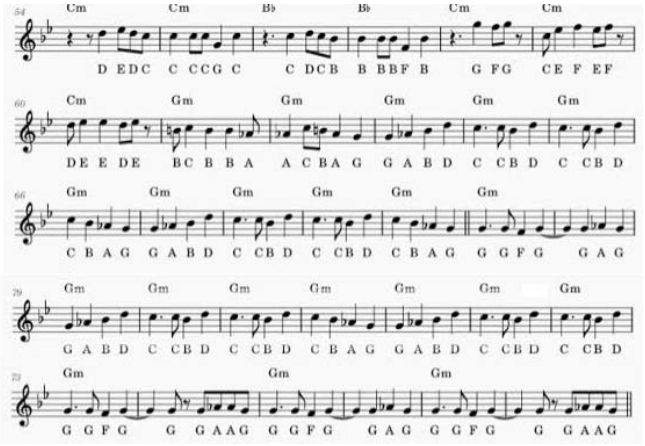

Fig. 9 Sheet of most viewed Indian music

VII. Conclusion

Historically, cultures flourished in isolation, and so did their music, with their links to the different moods that it generated. In today's interconnected world, likened to a village, through instant telecommunication networks, there is a need for concerted efforts to create music that can truly be called 'world music', that generates moods and emotions across all cultures. A successful music-to-mood cognition technique has been developed, wherein music pieces are translated into digital machine language. A database of known music-to-mood associations using Thayer's model is established. When testing the universality of a given piece of music, it is input into a MIR algorithm, and the closest mood is identified. This technique was applied to the three most viewed songs in the world, representing Korean, Arabic and Indian origins. The results have provided insights into the basis of their popularity worldwide.

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