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Automatic Instrumental Raaga – A Minute Observation to Find Out Discrete System for Carnatic Music

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Abstract

The objective of this paper is to evolve a system, which automatically mines the raaga of an Indian Classical Music. In the first step Note transcription is applied on a given audio file in order to generate the sequence of notes which are used to play the song. In the next step, the features related to Arohana – Avarohana are extracted. The features of two/three songs are then selected in random and given as input to the training system. Totally songs of 72 melakartha raagas and 45 janya raagas are considered. Subsequently, work testing is done by extracting features of one or two songs of each raaga, which are given as inputs in the training part. The generated output indicates the identification of each raaga. Unique labeling has been done for each raaga, for the system to identify the set of trained raagas. In this work 7 instruments namely Veena, Saxophone, Violin, Nadaswaram, Mandolin, Flute and Piano are used. The database generated is trained and tested by using (1) Gaussian Mixed Model (2) Hidden Markov Model (3) K-Nearest Neighbor using Cosine distance and Earth Mover Distance to draw appropriate conclusions.

Keywords: *Raaga, GMM, HMM, K-NN, Cosine Distance, Earth Mover Distance*

1. Introduction

As has been well said by William Shakespeare, "The world is like a stage. All men and women are actors and actress." When the entire world is at peace, when all things are tranquil and all people obey their superiors- Children to their parents, students to their teachers, common people to Elite, workmen to their superiors, then Raagas can be perfected. It may be a raaga of life or raaga of an Art.

When desires and passion do not turn into wrongful paths, things can be perfected. This doctrine could as well apply "Perfect Raagas" which have its cause. It arises from equilibrium. It arises from righteousness and Righteousness arises from the meaning of the Cosmos. Hence, one can speak about raagas, only with the meaning of Cosmos [5, 18].

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The assumption of inter-disciplinary study is an innovative theme, re-emerging in an academic research. It is rather a break from the norm of the past 200 years, where traditional scholars in one area of study and ascertain every microscopic detail. Whereas, inter-disciplinary study involves a macroscopic view, allowing to merge together a variety of fields in order to help and perceive the meaning of the Cosmos and push academic research in new directions.

The goal of this paper is to recognize the South Indian Classical Raagas (SICR) Viz: “Melakarta Raagas” characterized by several attributes like Vaadi – Samavadi, Arohana – Avarohana and Pakad, besides the sequence of notes.

2. Carnatic Music

The Southern-States of India, where the Carnatic music regions cover are Kerala, Tamil Nadu, Andra Pradesh and Karnataka. An attentive reader will observe the resemblance with our subject Indeed; it appears this rhythm got its origin in the southern regarding Karnataka. India is as big as Europe, without former Russia, it is quite clear that different languages, cultures will occur all along this boundaries and put its mark on the Arts and Culture.

The fundamental difference between Hindusthani and Carnatic states [8] is, that Hindusthani states use the Devnagari script, while the Dravidian script is being used in almost all the Carnatic states (Tamil, Telugu, Malayalam) script as we find diversity in Indian entity with multiple differences in the society not only in the aspect of culture, dress, diction and food but also in the traditions, at this juncture, mention may be made are prevailing. Following are Some of famous "Dakhini" musicians are: E.Gayathry (veena), Balmurali Krishnan (vocal, violin), T.N.Krishnan (violin),Vikku Vinayakram (ghatam). Musical instruments: Karnatic violin, veena, nadaswaram, ghatam, mridangam, tavil. The musical forms in South-India have its origin, for vocal use. These compositions are also used for different instruments adapting the songs into their musical and technical possibilities. As we all know music is available in two different structures:

One is Music for educational use and the second is music ascribed for the concert platform. (abhyasa gana and Sabha gana)

2.1. Types of Compositions

The Carnatic music is rich in compositions. There are many more compositions in different raagas, talas, languages and styles composed by great saints, philosophers, poets and historians of different periods. It is, therefore, emphasized that content in Carnatic music has a wide range, from the religious to the romantic. Most of the composers being great musicians as well as lyricists were Vaggeyakaras, which means, they composed the tune and the lyrics one by one. The process and complexity found in Carnatic compositions is definitely inspiring. Some songs are so easy that tiny aged child would be able to repeat it after hearing it just once. Generally musicians try to re-create and interpret these compositions relying largely on their own aesthetic sense besides what they have ascertained from their gurus. They memorize the entire process and try to render them methodically and soulfully. Generally an average professional's repertoire would be anywhere between 300 and 500 compositions but sometimes, there are artistes who have memorized over 1000 and above pieces.

A typical composition in Carnatic music, generally three major sections:

1. Pallavi
2. Anupallavi
3. Charanam

Compositions can basically be classified into two types:

- **Abhyasa Gana:** Those that have been designed for practice purposes to improve one’s technical skills and virtuosity.

- **Sabha Gana:** Those that have been designed for the purpose of performing in front of an audience.

3. Melakarta Raagas

Melakarta is a collection of fundamental raagas in Carnatic music. Melakarta raagas are well-known as parent raaga as one study well established, other raagas may be generated. In Hindustani music that is equivalent of Melakarta. There are 10 thats in Hindustani music, though the commonly accepted melakarta scheme has 72 raaga. A melakarta raaga is sometimes called as mela, karta or sampoorna as well.

3.1. Rules for Melakarta

The following are the Raaga characteristics features to be considered Melakarta.

- Chronologically, they are sampurna raaga - they contain all seven swaras of the octave in both upword and downword scale [1-2].
- They are also known as krama sampurna raaga - that is the sequence is strictly ascending and descending in the scales, without any jumps or hap harard notes[9].
- The upper shadjam is generally included in the raaga scale [6].
- The upword and downword scales must have the same notes.

3.2. Melakarta Scale

Each melakarta raaga has a different scale. This scheme aims at the lower Sa, upper Sa and Pa as fixed swaras, with the Ma having two variants and the remaining swaras Ri, Ga, Dha and Ni as having three variants in each [8]. This constitutes to 72 seven-note combinations referred to as the Melakarta raaga as follows.

There are twelve semitones of the octave S, R1, R2=G1, R3=G2, G3, M1, M2, P, D1, D2=N1, D3=N2, N3. It is rather inevitable that melakarta raaga must necessarily have S and P, one of the M's, one each of the R's and G's, and one each of the D's and N's. Also, R must necessarily precede G and D must precede N. This gives $2 \times 6 \times 6 = 72$ raaga. Conspicuously finding melakarta raaga is a mathematical process. The “raaga” and the “scale” may be observed by following a simple set of rules.

A raaga which has a subset of swaras from a parental raaga is said to be a janya (which means born or derived from) of that Melakarta raaga. Every raaga is the janya of a melakarta raaga. Janya raaga its relevant notes found in more than one melakarta raaga said to be are assigned (or associated) with the parent Melakarta based on subjective notions of similarity. This is apparently clear for raagas that have less than seven notes. For any of such raagas, it can be associated with a Melakarta which consists of different swaras. In such cases, For example, Hindolam has Rishabam and Panchamam missing. Hence, it could be considered a janya of Todi (Hanumatodi) which has shuddha rishabam or with Natabhairavi which has a chathusruthi rishabam. It is generally associated with Natabhairavi.

4. Raaga Database

The raaga database comprises of seventy two melakartha raagas. The recordings were primarily Instrumental recordings of violin, flute, Mandoilin, Nadaswaram and saxophone were included also as instruments [10-11]. Selections were drawn from general song and not the alapana and tanam forms where there is no mridangam (percussion) accompaniment. There after the frequencies of the accompanying instruments are filtered.

5. Technical Work Preparation

The main objective of this paper is to develop a system which automatically mines the raaga of an Indian Classical Music. The Figure 5.1 clearly shows the configuration of the proposed system. As a first step, Note transcription [18] is applied on a given audio file to ascertain the sequence of notes used to play the song.

In the next step, the characteristic features related to Arohana – Avarohana are extracted. These features are given to (i) GMM (Gaussian Mixture Model) [1] (ii) HMM (Hidden Markov Model) [2] (iii) KNN (K- Nearest Neighbor) with Cosine distance (iv) KNN with Earth Mover Distance (EMD) [3][4] for training and testing the system.

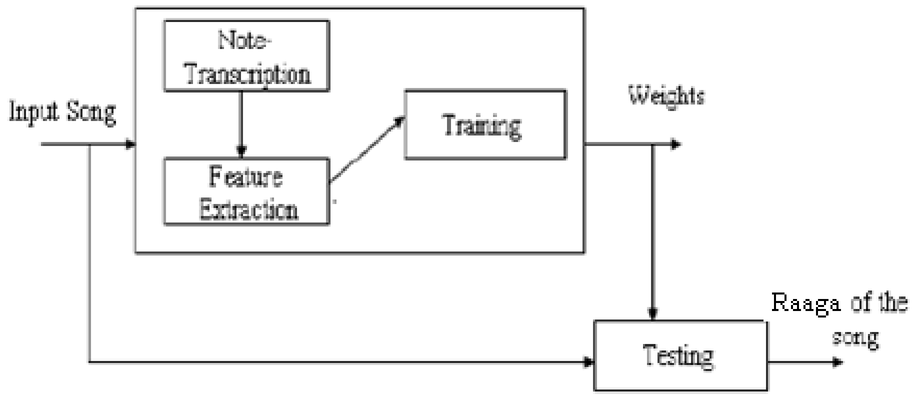


Figure 5.1. System Structure

5.1. Note Transcription

In order to identify the raaga of the songs, the one by one of notes used to play the song must be known. The process of identifying the sequence of notes *i.e.* the swara script is called as Note Transcription [18, 2, 1]. For Indian classical music, Note Transcription process itself is a very challenging task Music is represented as signal, so Note Transcription involves signal Processing techniques so that it could attract the attention of the audience. Music can also be defined as a melody composed by combination of swaras, where swara is combined and built of set of frequencies namely fundamental frequency and harmonic frequencies. The human perception of these set of frequency is generally called as Pitch [16,18].

The first step in Note Transcription [17] is definitely identifying all the various frequency segments in the song called as 'Frequency Extraction'. Fundamental frequency of each segment is calculated by using the Autocorrelation method [5] with a frame-size of 50ms. To simplify, the type of the audio file taken as input is monophonic song with a single sound-source. System can be enhanced further for recorded Polyphonic music, by applying multi-pitch detection techniques described in [9,18,2]. After listing all the frequency segments in the audio file, each such segment has to be converted into its corresponding swara. That has illustrated in Figure 5.2 shows a graph where list of fundamental frequencies of few Melakartha Raagas suitably plotted. The time duration of the song is 40sec.

The following Figure shows the variations of Frequency (Hz) with Time(s) of few arohana, avarohana Raagas.

The following are the Notes and their Basic frequencies

Sa = 130.0000; R1 = 134.1935; R2 = 138.6667; R3 = 144.4444

G1 = 154.0741; G2 = 156.0000; G3 = 162.5000; M1 = 173.3333
M2 = 175.5000; Pa = 195.0000; D1 = 205.4321 D2 = 208.0000
D3 = 216.6667; N1 = 231.1111; N2 = 234.0000; N3 = 243.7500

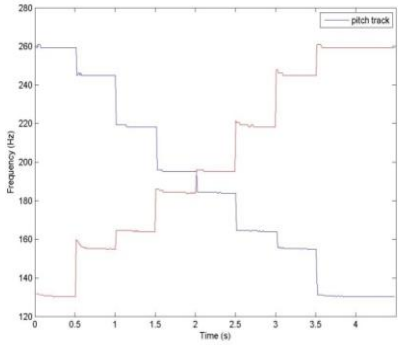


Figure. 5.2(a)
Name: Ratnangi
Arohana: S R1 G1 M1 P D1 N2 S'
Avarohana: S' N1 D1 P M1 G1 R1 S

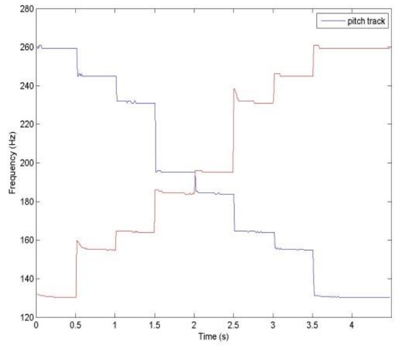


Figure. 5.2(b)……….
Name:Kanang………
Arohana: S R1 G1 M1 P D1 N2 S'
Avarohana: S' N2 D1 P M1 G1 R

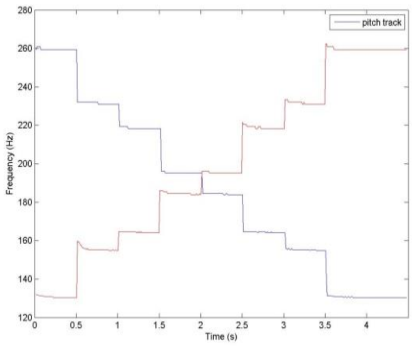


Figure. 5.2(c)
Name: Ganamurti
Arohan : S R1 G1 M1 P D2 N2 S'
Avarohana: S' N3 D1 P M1 G1 R1 S

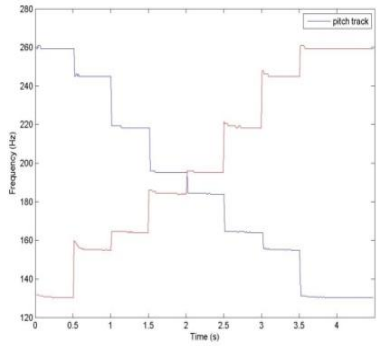


Figure. 5.2(d)
Name: Vanasapati
Arohana: S R1 G1 M1 P D1 N3 S'
Avarohana: S' N2 D2 P M1 G1 R1 S

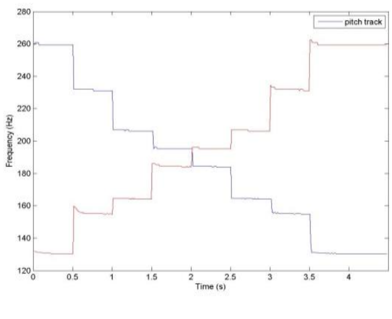


Figure. 5.2(e)
Name: Manavati
Arohana: S R1 G1 M1 P D2 N3 S'
Avarohana: S' N3 D2 P M1 G1 R1 S

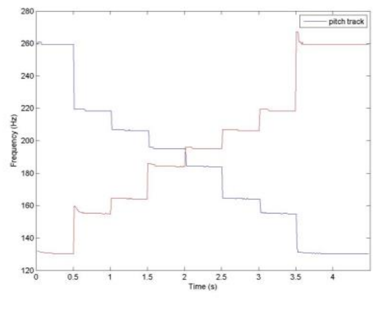


Figure. 5.2(f)
Name: Tanarupi
Arohana: S R1 G1 M1 P D3 N3 S'
Avarohana: S' N3 D3 P M1 G1 R1 S

Figure. 5.2 (A-F). Fundamental Frequency List Graphs for Few Melakarta Raagas

In Indian Classical Music, the relationship between swara and the frequency used to play it is not fixed. It generally depends on the fundamental frequency of the note called 'Sa', which is called as 'Shruti' or 'Scale' of the song.

The main frequencies of all swaras are related to Shruti with a defined ratio as shown below.

The Ratios are as below

Sa---1 Ma2---729/512	Re1---256/243 pa ---3/2
Re2--- 9/8 dha1---128/81	Ga1--- 32/27 Dha2---27/16
Ga2--- 81/64 ni1----16/9	Ma1---- 4/3 Ni2----243/128

Shruti is highly variable in Indian Classical Music. So, worthy point that one should bear the in this process one of the important tasks is to find out which fundamental frequency corresponds to the frequency of swara 'Sa'. In our system the scale of the song is fixed to 130Hz for piano.

Once the Scale is known, other frequency segments are mapped according to the defined ratio into the 36 swaras of Mandra, Madhya and Taara saptaka [13].

6. Experimental Studies

This paper highlights the findings on research and the contributions of this paper and also gives the direction for future research.

In the present paper a system has been developed which would listen to a musical instrument and attempt to recognize the raga [12]. The contributions from this paper can briefly be summarized as follows.

1. A database has been developed for raaga identification using seven different instruments
2. Four alternative approaches have been proposed, and implemented as classifiers to test their suitability for raaga recognition from instrument. These approaches are
   a) Gaussian Mixture Model approach [1]
   b) Hidden Markov Models approach [2,15]
   c) K-Nearest Neighbor with Cosine distance measure [3-4]
   d) K-Nearest Neighbor with Earth Mover Distance as distance measure [3-4]

7. Results and Discussions

Recognizing raagas from music has gained immense attention recently. With the increasing demand for human computer interaction, it is necessary to understand the raagas of the instrument. For training and testing of the method, data is collected from the existing database with due verification relating to melakarta ragas [13]. The 72 melakarta raagas for training, of them, a few raagas were specifically selected and tested. Then it is found that all the tested raagas are well recognized. In another case, the 72 melakarta raagas for training and another 42 raagas for testing are used. The experiments were performed pertaining to an instrument raagas.

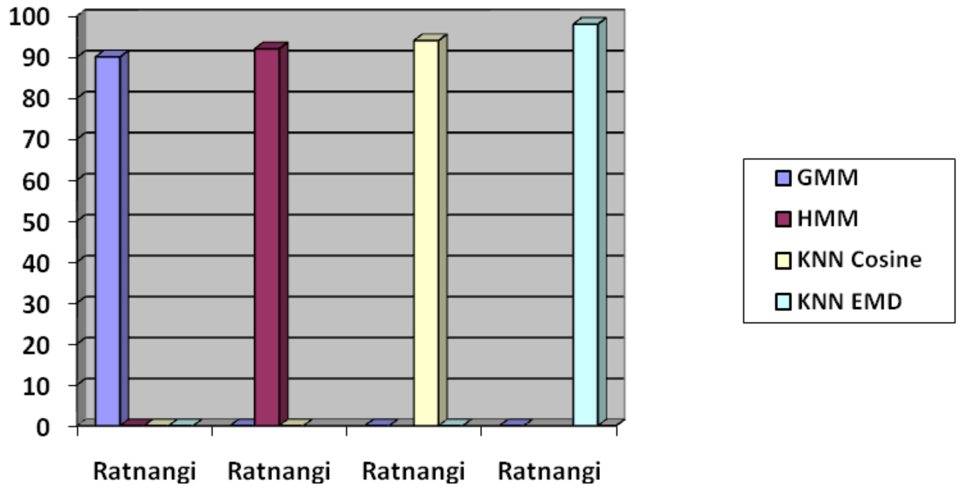
Everybody, well aware of the fact that raaga in an Indian Music is a very complex structure. The sequence of notes used to play the songs is apparently based on the raaga. Here, we analyze the sequence of notes for raaga identification. The objective of the present work is to develop a system which automatically mines the raaga of an Indian Classical Music [14].

The arohana – avarohana pattern is well defined for each raaga so it is very useful feature in identification of the raaga.

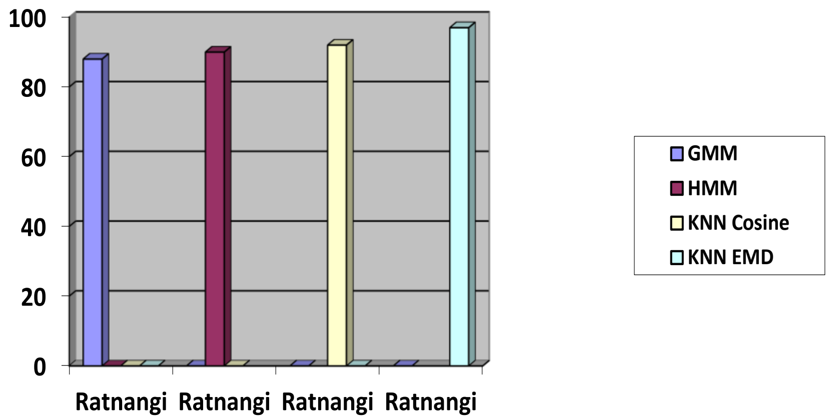
We have used 7 instruments namely Veena, Saxophone, Violin, Nadaswaram, Mandolin, Flute and Piano. Each instrument constitutes of 72 raagas (72 * 7 = 504). The database generated is trained and tested using (1) GMM (2) HMM (3) KNN using Cosine distance and KNN using Earth Mover Distance. The confusion matrix is obtained for each study. The results obtained show that best results are obtained with KNN with Earth Mover Distance.

The same is illustrated under two heads viz:

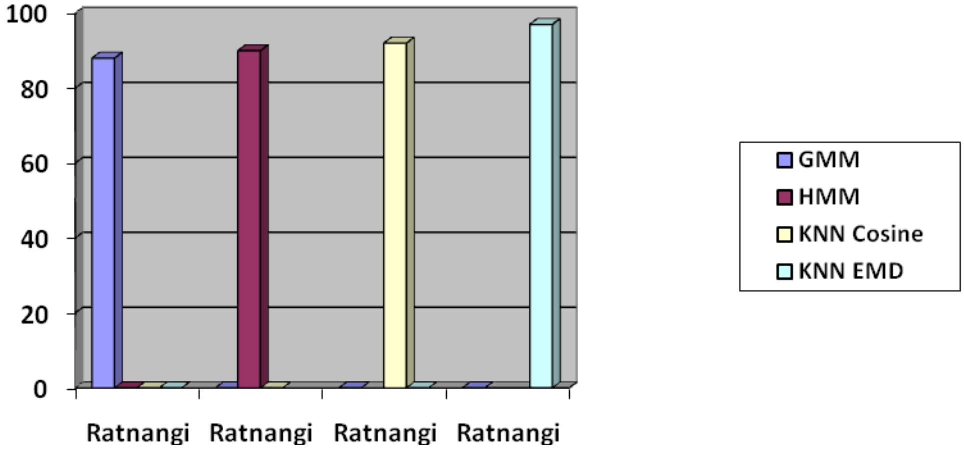
7.1. Melakarta Raaga



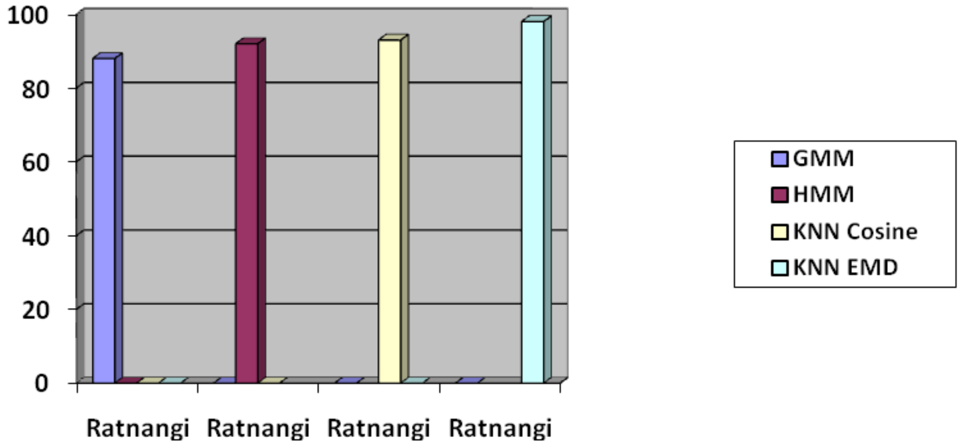
Graph 7.1. Results of the Rathangi raaga with Veena



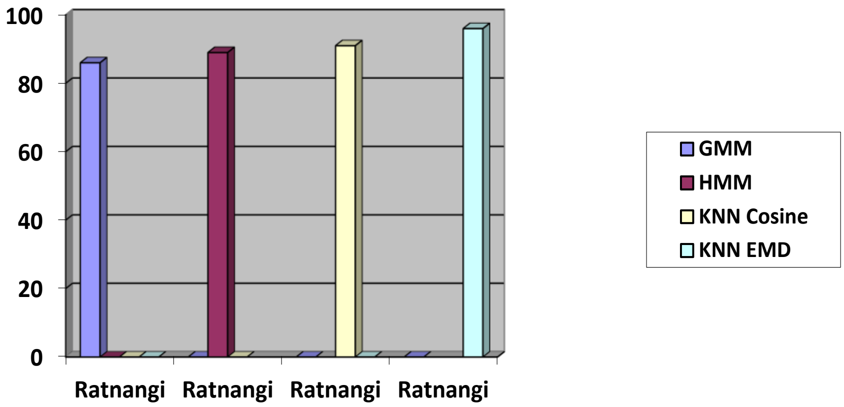
Graph 7.2. Results of the Rathangi raaga with Saxophone



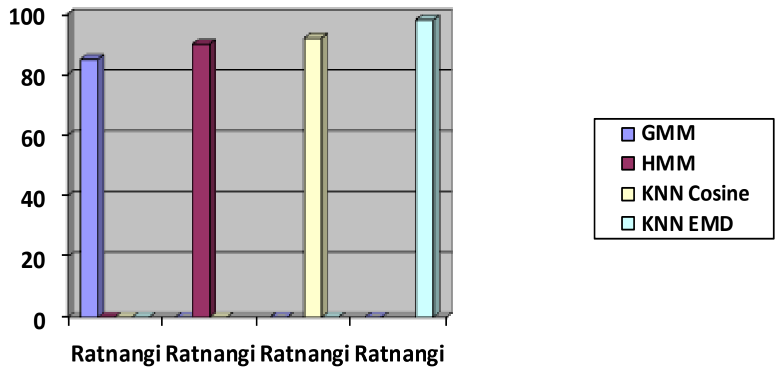
Graph 7.3. Results of the Rathangi raaga with Violin



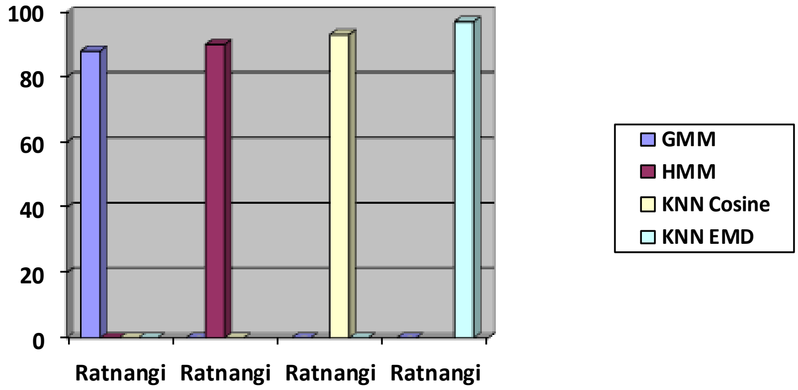
Graph 7.4. Results of the Rathangi raaga with Nadaswaram



Graph 7.5. Results of the Rathangi raaga with Mandolin

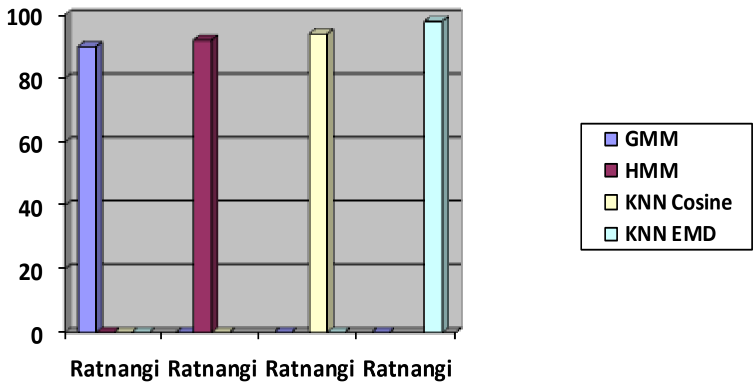


Graph 7.6. Results of the Rathangi raaga with Flute

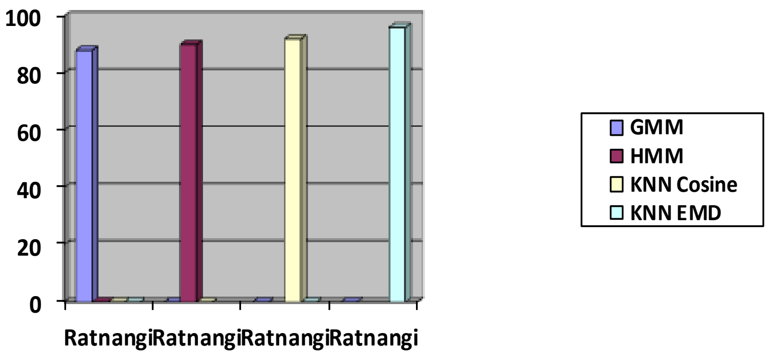


Graph 7.7. Results of the Rathangi raaga with Piano

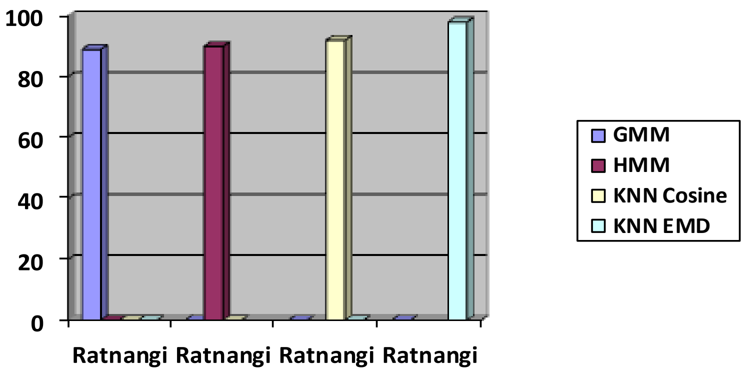
7.2. Janya Raaga



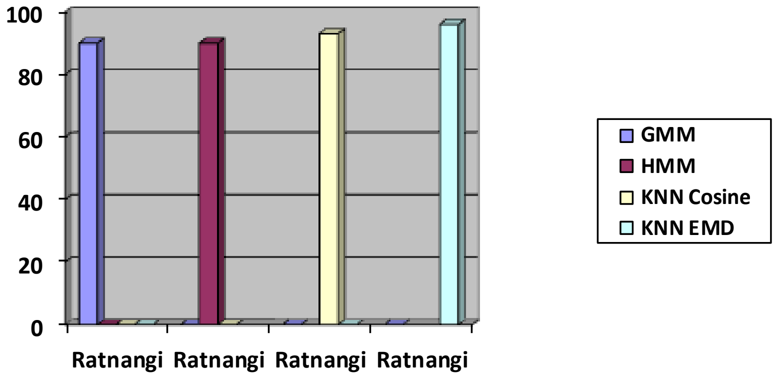
Graph 7.8. Results of the Deshi raaga with Veena



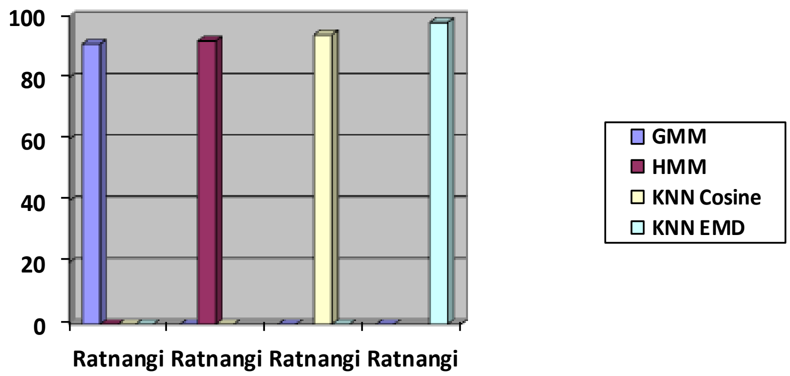
Graph 7.9. Results of the Deshi raaga with Saxophone



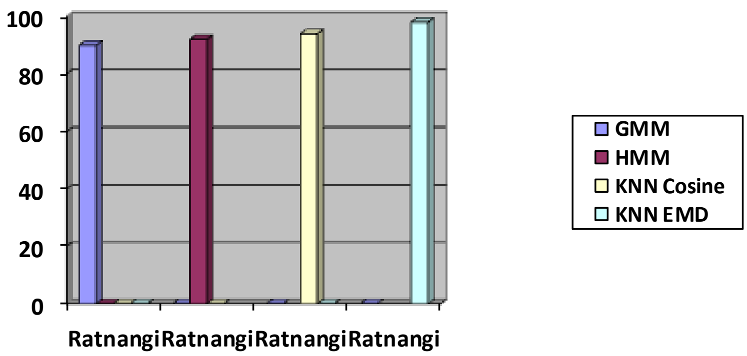
Graph 7.10. Results of the Deshi raaga with Violin



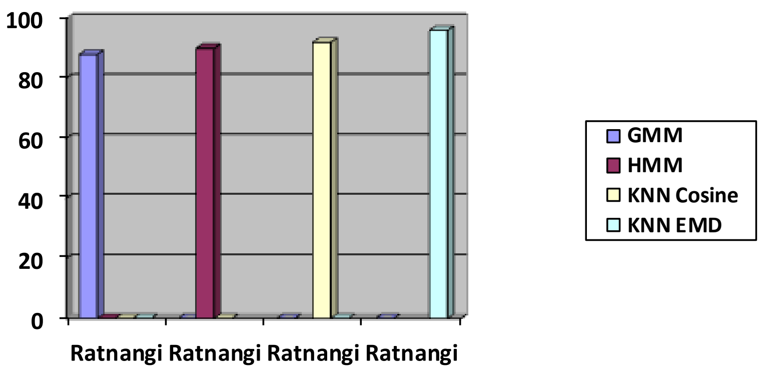
Graph 7.11. Results of the Deshi raaga with Nadaswaram



Graph 7.12. Results of the Deshi raaga with Mandolin



Graph 7.13. Results of the Deshi raaga with Flute



Graph 7.14. Results of the Deshi raaga with Piano

8. Conclusion

The fundamental frequencies of different instruments were determined to different raagas. The various results for the different instruments for same melakartha raaga plotted in Graph 7.1 to Graph 7.7. As can be seen from the figure, the raaga identification with

KNN with EMD is better than KNN with cosine, HMM and GMM. Later the results of janya raagas are also compared between the output KNN with EMD is better than KNN with cosine, HMM and GMM as shown in Graph 7.8 to Graph 7.14.

9. Future Scope of the Work

In the present work, a database is developed for 72 Melakartha raagas and 45 janya raagas with seven different instruments. Different classifiers have been applied to the developed music retrieval system to identify the raagas. The work needs extensive experimentation with many other instruments to establish the efficacy of classifiers across the instruments. The future work needs to concentrate on an overall system which should be able to recognize the raaga along with a combination of singer identification coupled with instrument identity.

References

[1] Tarakeswara R. B., "Recognition of Melakarta Raagas with the help of Gaussian Mixture Model", International Journal of Advanced Research in Computer Science, vol. 1, no. 3, Sep-Oct, **(2010)**, pp.445-448.

[2] Tarakeswara R. B., "Automatic Raaga Identification System for Carnatic Music Using Hidden Markov Model", Global Journal of Computer Science and Technology, vol. 11 no. 22 , December, **(2011)**, pp.1-9.

[3] Tarakeswara R. B., "K-Nearest Neighbour and Earth Mover Distance for Raaga Recognition", International Journal of Computer Applications, vol. 3 no.5, November, **(2011)**, pp. 30-38.

[4] Tarakeswara R. B., "Automatic Melakarta Raaga Identification System : Carnatic Music", International Journal of Advanced Research in Artificial Intelligence, vol. 1 no. 4, **(2012)**, pp. 35-42.

[5] Rajeswari S. and Geetha T. V., "Swara Indentification for South Indian Classical Music", ICIT' 06 Proceedings of the 9th International Conference on Information Technology, Bhubaneswar, 18-21, December, **(2006)**, pp. 143-144.

[6] Campbell H., "The contribution of the legato transient to instrument identification", E.P.A.Jr (ed) Proceedings of the Research Symposium on the Psychology and Acoustics of Music, Lawrence, University of Kansas, **(1978),** pp. 30-44.

[7] J. Viterbi (1967), "Error bounds for convolution codes and an asymptotically optimal decoding algorithm", IEEE Transactions on Information Theory, vol. 13, April, **(1967)**, pp. 260-269.

[8] Bhatkande.V (1934), "Hindusthani Sangeet Paddhati. Sangeet Karyalaya", **(1934)**.

[9] Sagan.C(1985), Hesse.H (1943), "The Glass Bead Game : Magister Ludi", New York, Henry Holt and Company, **(1943)**.

[10] Y. E. Kim and B. Whitman, "Singer identification in popular music recordings using voice coding features", Proceedings of the3rd International Conference on Music Information Retrieval (ISMIR), Paris (France), October **(2002)**.

[11] Clark M., "Dependence of timbre on the tonal loudness produced by musical instruments", J. Audio. Eng. Soc., vol. 12, pp. 28-31.

[12] Eagleson H. W., Eagleson, O. W., "Identification of musical instruments when heard directly and over a public-address system", J. Acoust. Soc. Am., vol. 19, pp. 338-342.

[13] Strong C., "Perturbations of synthetic orchestral wind instrument tones", J. Acoust. Soc. Am., vol. 41, pp. 277-285.

[14] Schroeder. M. R. (1968), "Period histogram and product spectrum: New methods for fundamental-frequency measurement", Journal of the Acoustical Society of America, vol. 43 no. 4, **(1968)**, pp. 829-834.

[15] A. Prasad, "Gender Based Emotion Recognition System for Telugu Rural Dialects using Hidden Markov Models", International Journal of Computing, vol. 2 no. 6, June, **(2010)**, pp. 94-98.

[16] S. Dixon, "Multi-phonic Note Identification", Proc. of the 19th Austral. Conference, Melborne, **(1996)**.

[17] W. Chai and B. Vercoe, “Folk Music Classification Using Hidden Markov Models”, Proc. International Conference on Artificial Intelligence, June, **(2001)**.
[18] Gaurav P., Chaitanya M. and Paul I., “TANSEN: A System for Automatic Raga Identification”, in the Proceedings of the 1st Indian International Conference on Artificial Intelligence (IICAI),Hyderabad, India, **(2003)**, pp. 1350-1363.