Classification of 72 Melakartha ragas using PAM clustering method: Carnatic Music

K. Praveen kumar, P.Subbarao, Venkata Naresh Mandhala, Debrup Banerjee

Abstract*: *Carnatic music is a popular music in south Indian music. Carnatic ragas are the most critical combination of saptaSwaraswhich are arranged in Arohana(ascending) and Awarohana(descending).It is very challenging and interesting task to find the similarities among them thathelp the learning community to find which ragas are to be learned as a group. In this work we investigated the methods to find the similarity among 72Melakartha ragas using raga symbols as features. We considered raga signatures as text that represents the raga; by representing the raga structure in the form of feature matrix we investigated the similarity among the ragas using binary, cosine and Manhattan distance measures. Based on the similarity results we clustered the ragas. Further we took the expert opinion on this clustering of ragas and applied classification techniques to study the performance of classification algorithms.

Index Terms*: *Carnatic music, Raga, sapta swaras, Melakartha ragas, similarity, arohana, avarohana.

I. INTRODUCTION

Data mining is a versatile technology that can be applied to rich kinds of applications, among that Music is one application area. Music as a Universal language it can be expressed suing certain frequencies, in India these frequencies called as Swaras. The popular word related to music is "SaptaSwaralu" (seven notes) Sa, Re, Ga, Ma, Pa,Da,Ni or(S,R,G,M,P,D,N) . But with variations to these seven Swaras the total Swaras used in Indian music are 12 those are Sa, R1, G1/R1, G2/R3, G3,M1, M2, D1, D2/N1, D3/N2, N3. In this R, G and D, N shares frequencies. With the composition of these 12 Swaras ragas are manifested.

Raga is a combination of the 12 Swaras and each raga has its separate structure. Ragas are majorly categorized into two categories MELAKARTHA and JANYA ragas. MELAKARTHA ragas are base and complete ragas, they contain 7 Swaras in arohana and avarohana (i.e. reciting the Swaras base frequency to high frequency and high frequency to base frequency in respectively). The total melakartha ragas are 72 and these are called parent ragas. From the parent ragas many new ragas are evolved by the permutations and combinations of the Swaras and these ragas are called JANYA ragas.

JANYA ragas are different from MELAKARTHA ragas in many ways. JANYA ragas need not to contain whole 7 Swaras and even in arohana and avarohana need not to have same number of Swaras. Some JANYA ragas may contain sameSwaras in arohana and avarohana, some ragas may contain different number of Swaras in arohana and avarohana. For example, Raag Abheri consists of Swaras S G2 M1 P N2 S in arohana and S N2 D2 P M1 G2 R2 S in avarohana and Raag ChitrambariAmruthavarshini consists Swaras S G3 M2 P N3 S in arohana and S N3 P M2 G3 S.there is now raga with less than 5 Swaras it is a notable thing. Raga identification using computational methods work is a promising work and it can be done in many ways. In our paper we used vector representation of MELAKARTHA ragas. And we worked on 72 MELAKARTHA ragas, each raga is represented with a vector that describes out of 12 Swaras which Swaras are present in the specific raga and which are absent. Later we identified the similarity among the ragas using cosine similarity measure and grouped them into 4 categories using PAM (Partitioning Around Medoid) clustering method. This grouping will help the music learning community and teaching community in selecting the ragas teaching order. The idea is the student will easily learn the ragas which are close to each other than the ragas which are dissimilar. Later we used classification methods to classify the partitioned groups and tested their accuracies.

II. RELATED WORK

This work mainly focuses on best grouping of MELAKARHTA ragas based on their structure[8] so that learning community can find it helpful in learning the highly similar ragas first and dissimilar ragas later. In this direction our work is first of its kind. Surendra Shetty et.al[1] developed a mining method by extracting the raga structure from audio songs. And classified using Multi-Layer Perceptron and they achieved 95% accuracy in classifying raga. In another work Shreyas Belle et.al [2] studied on intonation of Swaras in different ragas and compared the difference among different ragas. For their work they used Hidden Markov Models (HMM) and the accuracy attained is 87% in raga identification.Gouravpandeyet.al[3] proposed a raga detection method using HMM with string matching algorithm, they worked on audio files. Each raga will have normally a specific style called PAKAD, by describing it they tried to identify the raga, the authors worked on Yaman Kalyan and Bhupali and the achieved accuracy is 87% on average two ragas. Our idea is that we are assuming that the raga is identified its structures along with the Swaras, but the Swara identification it self is a big task. Here we considered the raga structures in text format. The paper is further organized like this, In section 3 we describe the methodology used to cluster and classify the 72 MELAKARTHA ragas. In section 4 we discussed the obtained results and in section 5 conclusions and future work is proposed.

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III. METHODOLOGY

The Binary representation of each raga, a raga is represented with 12 Swaras, is differentiated withother ragas being absent of one or more specific Swarasout of 12. Fig 1 explains the procedure followed to perform the experiment. As a first step we represented the raga in binary vector the algorithm is explained below.In table 1 presented the first 6 ragas binary representation. Further we used cosine distance measure to find the distance among all 72ragas, later computed distance matrix that represents the distance among all ragas. Partitioning Around Medoid clustering method is used to find the clusters, for better clusters we have checked with random numbers K=2,K=3, K=4,K=5 and K=6, it is observed that K=4is giving largest silhouette value i.e. best clusters with low intra cluster distance and high inter cluster distance. After clustering the 72 MELAKARTHA ragas in to 4 groups, each raga is labeled with its group number for further classification task. The achieved accuracy with J48 decision tree and PART rule-based classification algorithms is 94.4%. All the experiments are performed using R statistical tool and WEKA.

Algorithm for representing the data in binary format

Input: ragas with its Swaras

Output: A matrix with Swaras

Construct a matrix with column names with12 Swaras

Each row represents a Melakartha raga

For each raga

if(Swara == column name of the matrix) then insert 1 in correspondent cell

else

Insert 0 in correspondent cell

End of For

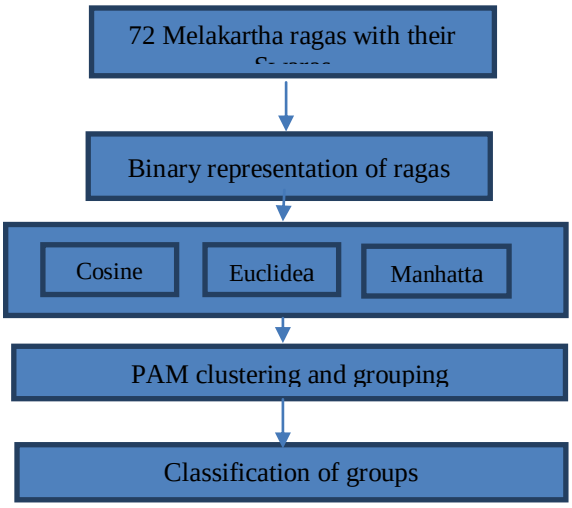

Fig. 1 Procedure followed for clustering and classification of 72 MELAKARTHA ragas

We have performed this experiment with other two distance measure Euclidean and Manhattan we found the results with cosine similarity are better than other two distance measures.

Table. I Binary representation of first 6 out of 72 MELAKARTHA ragas along with 12 Swaras

Name of the raga	s	r1	g1/r2	g2/r3	g3	m1	m2	p	d1	n1/d2	n2/d3	n3
Kanakangi	1	1	1	0	0	1	0	1	1	1	0	0
Rathnangi	1	1	1	0	0	1	0	1	1	0	1	0
Ganamurthi	1	1	1	0	0	1	0	1	1	0	0	1
Vanaspathi	1	1	1	0	0	1	0	1	0	1	1	0
Manavathi	1	1	1	0	0	1	0	1	0	1	0	0
Thanarupi	1	1	1	0	0	1	0	1	0	0	1	1

A. *Cosine similarity measure*

Cosine similarity[[4],[5]] measures the similarity between two non-zero vectors. That measures the cosine angle between the two vectors. It the similarity is close to 1 it tells that the two vectors are same, if similarity is towards zero tells that the two vectors or not similar. This measure is popular in finding document similarity.

B. *PAM clustering*

Partitioning around medoid clustering method, it is a partition-based clustering method, it uses medoid as a centroid to find the clusters. Medoid is the most appropriate central point that is near to the all points in that cluster. This algorithm initially selects the cluster representatives randomly and improves cluster quality by replacing the existing centroid point with suitable other representative. While performing this task it will check for the cost of modifying the representative. The algorithm will change the centroid if the cost of change is lower than the cost of previous cluster centroid.

C. *Naive Bayesian*

Naïve Bayesian classifier is a simple probabilistic classifier that works on Bayes theorem. It assumes features are independent to each other. It is extensively used method for text categorization, judging the document belongs to which category among multiple categories. According to Bayes theorem

$$Y=Argmax\ [P(C_k), P(X/C_k)]$$

D. *Random Forest*

Whenever a single classifier model fails to exhibit better performance, the ensemble of classifiers are used improve the performance of the model. In this method m number of decision trees are built on m number of boot strap samples drawn on training set. When it comes to classification decision of test sample it the results with classification is boot strap aggregation of m classifiers decisions.

E. *Multilayer Perceptron:*

It is a class of feed forward artificial neural network. Multilayer perceptron comprises of minimum 3 layers, an input layer, a hidden layer and an output layer. Input layer takes the input to build a model, a hidden layer consists of neurons these neurons will use activation function to lean the weights of network.

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Multilayer perceptron used back propagation algorithm (BP) to learn the network. In BP the outputs from hidden and output are calculated on forward pass and whereas the connection weights <Wi,Vi>among the layers are updated in backward pass. Most commonly used activation function for output calculation at each hidden and output neuron is Sigmoid function.

Support Vector Machines: Derives the boundary as a hyperplane y=Wx+b that separates two classes. Here <x,y> represents the training data, the unknown slope and intercept <W,C> are identified by a QP solver. Once the unknowns are identified the class label of the test samples is predicted against Wx+C. If predicted y is greater than zero positive class else negative class.

F. *K Nearest Neighbor:*

K Nearest Neighbor is a non-parametric classification method, it is also called as lazy learner. In this method a set of training samples are given, based on K number of nearest neighbors from training data to given test sample, the class label of the test sample is predicted. Here the K, the number of neighbors is user's choice and computed based on a similarity measure.

IV. Results and Discussion

Before performing the clustering, to find the optimal clustering number we performed elbow method, that shows that how many numbers of clusters are good. Fig 2 shows the optimal number of clusters as 4. Fig. 3 shows the hierarchical clustering dendrogram that depicts the 4 clusters of 72 MELAKARHTA ragas. This clustering happened based on a specific pattern. In cluster 1 The first 6 ragas kanakngi, rathangi, ganamurthi, vanaspathi, manavathi, thanarupi the SwarasS,R1, G1, M1,P are same only D and N variated. Next 13 ragas fall in to cluster 2 because the chage in Swara G. Again next 6 ragas fall into cluster 1 because of variation in Swara Re. only raga 25th Mararanjani falls in to cluster 2 next 5 ragas fall into cluster 1. In a similar manner 72 ragas are grouped in to 4 clusters the list is shown in Table 2.

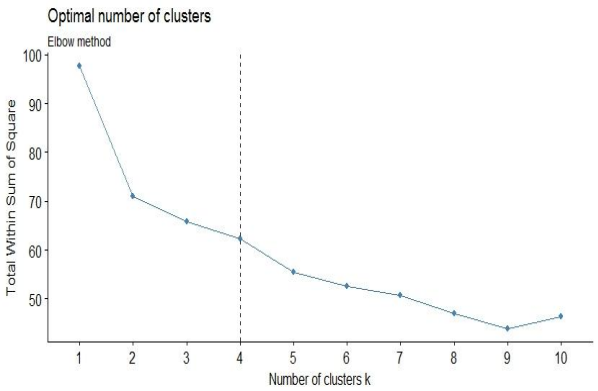

Fig. 2 Optimal number of clusters finding using elbow method

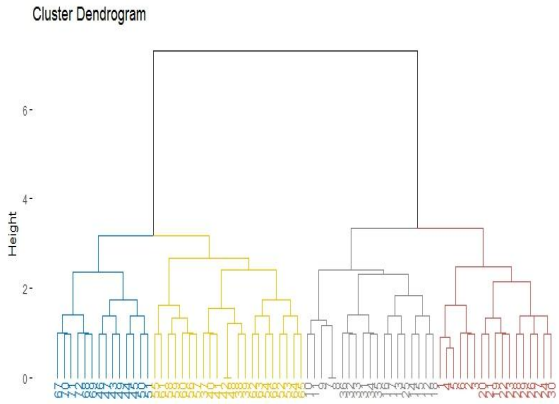

Fig. 3 Hierarchical clustering method dendrogram showing 4 clusters of 72 MELAKARHTA ragas

Table. II 72 MELAKARTHA ragas arrangement according to the 4clusters.

Cluster 1	Cluster2	Cluster3	Cluster4
Kanakangi	Senavathi	Salangam	Gavambodhi
Rathangi	Hanumathodi	Jalarnavam	Bhavapriya
Ganamurthi	Dhenuka	Jalavarali	Shubhapathuvarali
Vanaspsathi	Natakapriya	Navanitham	Shadvidhamargini
manavathi	Rupavathi	Pavani	Suvarnagi
thanarupi	Gayakapriya	Ragupriya	Dhavalambari
Jankardhavani	vakulabharanam	dhivyamani	Namanarayani
Natabairavi	Mayamalavagowla	Ramapriya	Kanavardhini
Kiravani	Chakravakam	Gamnashrama	Sucharitha
Karaharapriya	Suryakantam	Vishvambhari	Jyothisvarupini
Gwrimanohari	katakambari	Shyamalangi	Dhatuvardhani
varunapriya	Maharanjai	Shanmukapriya	Nasikabhushani
Charukeshi	Yagapriya	Simhendramdhyamam	Kosalam
Sarasangi	Ragavardhani	Hemavathi	rasikapriya
Harikhambhoji	Gangeyabhushani	Dharmavathi	
Dhirashankarabharanam	Vagadhisvari	Nithimathi	
naganandhini	Shulini	Kantamani	
	chalanata	Rishabhapriya	
		Lathangi	
		Vachaspathi	
		Mechakalyani	
		chitrambari	

The ragas are assigned group label based on the clustering and performed classification on the class labeled data. The results are shown in table3. J48 decision tree has classified the groups with 94.4% accuracy along with this PART (Projective Adaptive Resonance Theory) rule-based classifier also gave 94.4% accuracy. Next better performance is attained by Multilayer perceptron with 93.5% accuracy. JRIP (Java based Repeated Incremental Pruning to Produce Error Reduction) algorithm shown 91.6% accuracy further

Naïve Bayes and Random forest algorithms shown similar accuracy of 90.2%. Least performance is shown by K nearest Neighbor classifier with 83.3%.all the experiments are performed using WEKA [6] (Waikato Environment for Knowledge Analysis) software. The results are shown in a graphical format in Fig 5. In Fig.4 we show the extracted rules from J48 in this it shows that 5th raga is the root for the decision tree.

```
J48 pruned tree
a5 <= 0
|   a2 <= 0
|   |   a3 <= 0
|   |   |   a8 <= 0: group3 (3.0)
|   |   |   a8 > 0: group4 (3.0)
|   |   a3 > 0: group4 (11.0)
|   a2 > 0: group3 (19.0)
a5 > 0
|   a2 <= 0: group2 (18.0)
|   a2 > 0: group1 (18.0/2.0)
Number of Leaves  : 6
Size of the tree :   11
```

Fig. 4 Extracted rules from J48 classifier

Table. III Classification results of 8 classification methods

Classifier	Precision	Recall	F-measure	Accuracy
Naïve Bayes	88.9	100	94.1	90.27
SMO	88.09	100	94.1	88.88
MLP	88.2	93.8	90.9	93.05
Random Forest	88.9	100	94.1	90.2
J48	88.9	100	94.1	94.44
PART	88.9	100	94.1	94.44
JRIP	88.9	100	94.1	91.6
KNN	87.5	87.5	87.5	83.33

V. CONCLUSION

Raga classification is an interesting task in music mining field. In this paper we have tried to group the 72 MELAKARTHA ragas using cosine similarity by representing the ragas as vectors. This will help the learning and teaching community while learning which ragas must group so that student can learn the ragas easily. For this we used computational methods such as hierarchical clustering to group the ragas based on their cosine similarity measure. In this work we considered the ragas with their Swara structure. Later to evaluate the grouping we performed classification using 8 popular classification methods. Among them J48 decision tree and PART methods shown best classification result as 94.4%. In future, From the audio of these ragas can find the Swaras of the ragas and then can perform classification task to find the raga.

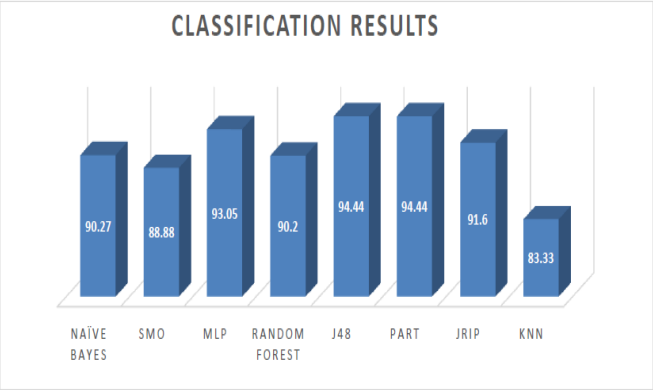

Fig. 5 Graphical representation of classification results

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