ISSN:0975-9646

Satish Ramling Sankaye et al, / (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 6 (3) , 2015, 2880-2883

Perspective Identification of Indian Musical Instrument Ghan and Sushir Vadya

Satish Ramling Sankaye[#1], S.C. Mehrotra[#2], U.S. Tandon[*3]

[#]*Department of Computer Science and Information Technology*
Dr. Babasaheb Ambedkar Marathwada University,
Aurangabad, India

[*]*Department of Physics, College of Natural and Computational Sciences,*
Haramaya University, Dire Dawa, Ethiopia

Abstract— **A lot of work has been done globally in the area of Digital Signal Processing for the recognition and identification of speech and for the study of Musical Instruments. This study presents experimental results of Identification of two musical instruments viz. *Ghan* and *Sushir Vadya* using Linear Predictor Coefficient (LPC) features and Linear Discriminant Analysis (LDA) as the Classifiers. During the experiment, sound emanating from different *Ghan* and *Sushir Vadya* instruments has been recorded as solo notes and then its LPC feature study has been carried out. The process has been conceived and performed to find significant results of about 94.44% musical instrument sound identification from 370 sound exerts using LDA method.**

Keywords — ***Ghan Vadya, Sushir Vadya,* Linear Predictor Coefficients (LPC), Linear Discriminant Analysis (LDA).**

I. Introduction

Music is an emerging and closely related topic with wide applications like media annotation, singer identification, music transcription, structured audio coding, information retrieval, detection, classification, and separation of Musical sound Signal [1]. Musical application is especially important, since musical sounds are designed merely for human audition. The study of music signal is useful in teaching and evaluation of music. Earlier studies reveal similarities in the spectral and temporal properties of musical audio signal [2] and speech signal. Hence, several techniques developed to study speech signal are employed to study music signals as well. Musical instrument Identification is edged on classification of single note (Monophonic), more than one instrument notes at a time (Polyphonic), distinction of instruments in continuous recording or Classification of family/genre [3] [4] [5].

Although Music cannot be limited in the borders of region, relation, or nation, they are classified on the basis of the orientation of the musical instruments and its wide use in particular geographical region. According to the *Natyashastra* of *Bharatha*, there are four classes of Indian musical instruments: Tata or *Tantu* (stringed), *Avanaddha* (percussion or drums), *Ghana* (bells, cymbals and gongs), and *Sushir* (wind) [6]. The present paper discusses *Sushir vadya* and *Ghana vadya* in detail.

Sushir Vadya is also known as *Sushira* or Aerophones. *Sushira* means 'hollow'. It is a musical instrument producing sound primarily by causing a body of air to vibrate, without use of strings or membranes, and without the vibration of instrument itself adding considerably to the sound. All wind instruments belong to this class. Our Study is limited specifically to *Bansuri*, *Shehnai* and *Harmonium* belonging to the family of *Sushir Vadya*.

Ghana Vadya also known as Idiophones, are solid instruments which do not need any further tuning. *Ghana Vadya* creates sound primarily by way of the instrument vibrating itself, without the use of strings or membranes. *Ghana Vadya* are probably the oldest type of musical instruments. They are made to vibrate by being hit hence the name Ghana, either directly with a stick or hand or indirectly, by way of a scraping or shaking motion. Various *Ghana Vadya* instruments, namely *Ghungaroo*, *Manjira*, Triangle and *Ghatam* have been studied.

This paper is organized as: Section 2 has brief collections and presentation of work most relevant to the present study. Section 3 is devoted to the LPC features and LDA method. Section 4 describes the data set used, the features, and the experiments performed to assess the performance of the proposed classifier. Finally, conclusions are drawn in Section 5.

II. Research Review

There has been a lot of research work in the area of Music Instrument Recognition (MIR) using different features set and many classification techniques. Some of the prominent research works are discussed below:

Antti Eronen and Anssi Klapuri [1] in their work Musical Instrument Recognition using Cepstral Coefficient and Temporal Features correctly recognized 94% instrument family and 80% individual instruments. They focussed on the autocorrelation sequence and then used LPC coefficient calculation with Levinson-Durbin algorithm for instrument identification.

Kim, Youngmoo E., and Brian Whitman [7] proposed Singer Identification in Popular Music Recordings. The System proposed by them uses features drawn from voice coding based on LPC after segmentation prior to singer identification.

Janet Marques and Pedro J. Moreno [8] proposed the classification of musical instruments using GMM and SVM Methods. The set of Features used by them were linear prediction coefficients (LPC), FFT based cepstral coefficients, and FFT based mel-cepstral coefficients. The success rate was 70% with LPC for determining the instrument source and the error rate was 30%.

Kitahara, Tetsuro, Masataka Goto, and Hiroshi G. Okuno [9] presented a method for musical instrument identification using the *F0-dependent multivariate normal distribution* which takes into consideration the pitch dependency of timbre. The method improved the recognition rates at individual-instrument level from 75.73% to 79.73%, and at category level from 88.20% to 90.65%, on an average, respectively. The Bayes decision rule with dimension reduction by PCA and LDA method.

Feature selection is one of the fundamental problems for Identification and recognition in digital signal processing. The most popular techniques for dimensionality reduction are Principal Components Analysis (PCA) and the Linear Discriminant Analysis. A. M. Martinez and A. C. Kak [10] have presented a study on the comparison between PCA and LDA techniques. PCA technique searches for directions in the data that have largest variance and subsequently it projects the data features onto it. PCA will compute a vector that has the largest variance associated with it. LDA will compute a vector, which best discriminates between the classes.

III. Features

A. Linear Predictor Coefficients (LPC)

LPC is generally used for speech analysis and re-synthesis. It transmits spectral envelope information and is used to construct vocoders where musical instruments are used as excitation signal to the time-varying filter estimated from a singer's speech [11]. LPC uses the Levinson-Durbin recursion to solve the normal equations that arise from the least-squares formulation. This computation of the linear prediction coefficients is often referred to as the autocorrelation method. Thus we tried to use the LPC feature vector.

The LPC feature vector can be represented by mathematical equation (1) as shown below:

$$\hat{x}(n) = \sum_{i=1}^{p} a_i x(n-i) \qquad \textbf{(1)}$$

where $\hat{x}(n)$ is the predicted signal value, $x(n-i)$ the previous observed values, and a_i the predictor coefficients.

The error generated is given by

$$e(n) = x(n) - \hat{x}(n)$$

where $x(n)$ is the true signal value and $\hat{x}(n)$ is the resultant value.

The Wave form of the Musical instrument along with its LPC features is shown in Fig 1 and Fig. 2 for the instruments called *Bansuri* and *Ghungaroo*.

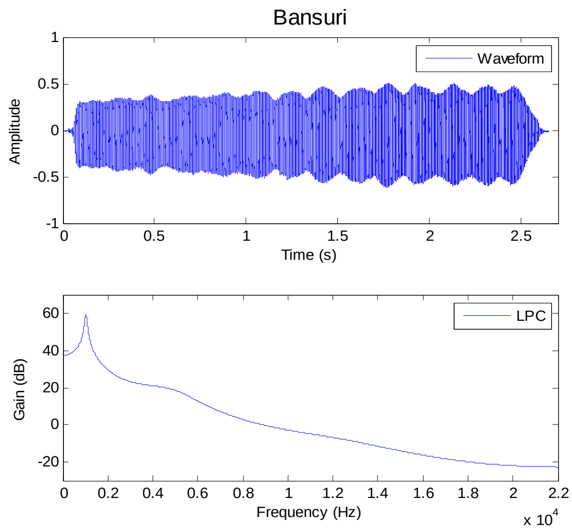

Fig.1. Waveform and LPC features set of Musical Instrument *Bansuri*

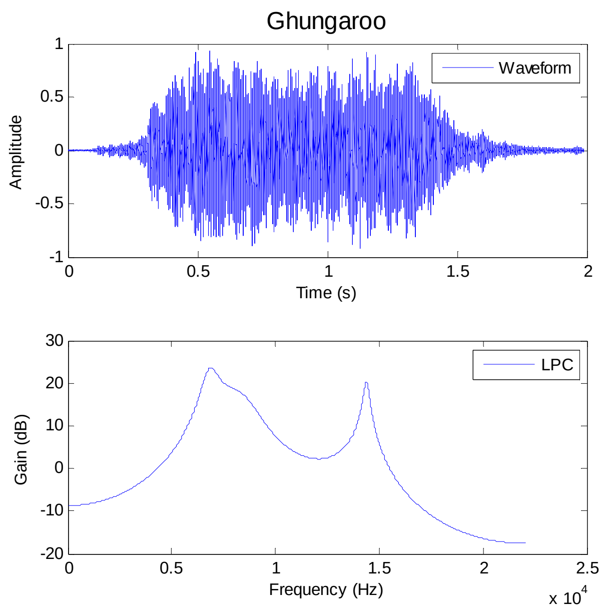

Fig.2 LPC features set of Musical Instrument *Ghungaroo*

B. Linear Discrimination Analysis (LDA) classifier:

Linear Discriminant Analysis (LDA), is also known as Fisher Discriminant Analysis (FDA). LDA has been widely used in face recognition, mobile robotics, object recognition and musical Instrument Classification [12] [13] [14].

In LDA, we compute a vector which best discriminates between the two classes. Linear Discriminant Analysis (LDA) searches for those vectors in underlying space that best discriminate among classes (rather than those that best describe the data). More formally, given a number of independent features relative to which the data is described, LDA creates a linear combination of these which yields the largest mean differences between the desired classes. Mathematically speaking, for all the samples of all classes, we define two measures:

1) One is called within-class scatter matrix. It is given by

$$S_w = \sum_{j=1}^{c} \sum_{i=1}^{N_j} (x_i^j - \mu_j)(x_i^j - \mu_j)^T,$$

Where x_i^j is the i^{th} sample of class j, μ_j is the mean of class j, c is the number of classes, and N_j the number of samples in class j; and

2) The other is called between-class scatter matrix

$$S_b = \sum_{j=1}^{c} (\mu_j - \mu)(\mu_j - \mu)^T,$$

Where µ represents the mean of all classes.

The goal is to maximize the between-class measure while minimizing the within-class measure. One way to do this is to maximize the ratio det[Sb]/det[Sw].

IV. EXPERIMENT AND RESULTS

In our work, Musical instrument identification is performed at individual-instrument level to evaluate the improvement of recognition rates by the proposed method based on 15 LPC Feature Vector. The recognition rate was obtained by 10-fold cross validation. The work has been done upon the Delta and Delta-Delta Features of LPC but there were no improvement in the result so it was ignored and continued with the original 15 features of LPC.

A. Dataset

All the files of Sound exerts were recorded in natural environment. Overall 370 files were extracted. These belong to seven different instruments like: *Bansuri*, *Shehnai*, *Harmonium, Ghungaroo*, *Manjira*, Triangle and *Ghatam*. In detail, 60 samples each of *Bansuri*, *Shehnai* and *Harmonium* recordings, 20 each of *Ghungaroo* and Triangle recordings, 90 of *Ghatam* recordings and 60 of *Manjira* are used as shown in Table I. The 370 sounds are partitioned into a training set of 244 audio files and test set of 126 audio files, preserving 66%, and having 34% analogy between the two sets, which is typical for the classification experiments. The sound samples were recorded at 16 bits depth with sampling rate as 44.1 KHz and file format as **.wav** file.

TABLE I
LIST OF MUSICAL INSTRUMENTS

Musical Instrument	Class	No. of Samples
Bansuri	*Sushir*	60
Shehnai	*Sushir*	60
Harmonium	*Sushir*	60
Ghungaroo	*Ghana*	20
Triangle	*Ghana*	20
Ghatam	*Ghana*	90
Manjira	*Ghana*	60

B. Results

Initially, from the sound sample we computed the 44 features of LPC. Out of these, preserving the data consistency, we discarded the last 14 values and by selecting the odd values we finally prepared 15 feature vectors for our proposed method. The experiment was carried out using 10-fold cross validation and 15 LPC Features. The highest mean accuracy of 94.44% was achieved by using standard Best First Decision Tree algorithm. The results of the classification are shown in the Table II the confusion Matrix. From the total 126 Musical Instrument exerts, 119 have been correctly classified whereas the number of incorrectly classified samples is 7.

TABLE II
CONFUSION MATRIX FOR ALL 7 INSTRUMENTS

Inst	1	2	3	4	5	6	7
1	16	1	0	0	0	0	0
2	0	19	0	0	0	0	0
3	1	2	17	0	0	3	0
4	0	0	0	7	0	0	0
5	0	0	0	0	6	0	0
6	0	0	0	0	0	35	0
7	0	0	0	0	0	0	19

1) *Bansuri*, 2) *Shehnai*, 3) *Harmonium*, 4) *Ghungaroo* 5) Triangle, 6) *Ghatam* and 7) *Manjira*

The LDA Classification for the entire seven instruments is shown in Fig. 3. It can be seen that the performance is quite satisfactory. The instrument can be very easily classified.

V. CONCLUSIONS

In this paper, we have proposed a method of classifying musical instrument signals using Linear Discriminant Analysis using the Linear Predictor Coefficient features. The result shows that the method is quite effective and it needs to be worked out on more number of musical instruments and number of samples. As only the small dataset of seven instruments are considered and it would be interesting to find whether or not the features scale well given a larger set of instruments. Future work will focus on increasing the number of instrument within the class as well as instruments belonging to other classes.

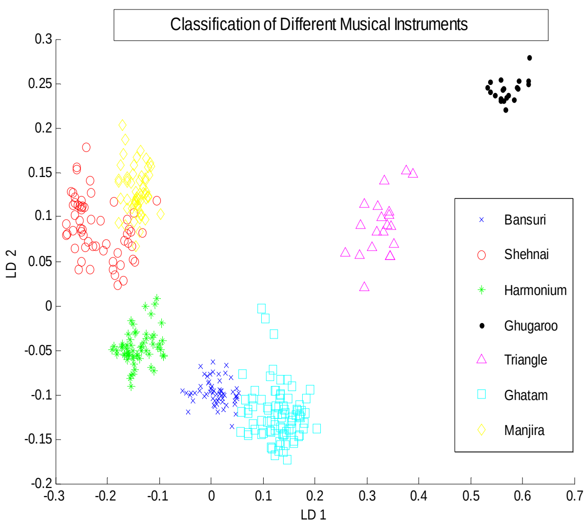

Fig. 3 LDA features set of Musical Instrument

ACKNOWLEDGMENT

We would like to thank Mr. Abhay Samant, Mr. Virkam Pawar and Mr. Dayanand Shinde, the Musicians who contributed their music data and guidance for the evaluation during our study. Our sincere thanks to Dr. R.R. Deshmukh, Head of CS & IT Department, who has been the source of inspiration. Also we extend our valuable thanks to staff & colleagues of Department of CS & IT, Dr. B.A.M. University, Aurangabad for their support and help.

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