Knowledge Engineering of Creative Musical Expressions Using Carnatic Music Ideology

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Abstract

The purpose of this paper is to propose a method to analyze creative music expressions of a performer in South Indian Classical Music (Carnatic Music). The method performs a qualitative classification of the extracted note sequences in a Carnatic music exposition by defining pattern classes. The classification attributes the note sequences in varying degrees to each of the classes. These pattern classes, based on the formalized Carnatic music theory, help in capturing the dynamics of a performer. This provides a framework for style-based music generation.

Introduction

Carnatic Music, a traditional classical music system of Southern India, built on a strong theoretical background, dates back to the age of Vedas (3000 B.C). The grammar of Carnatic music is sophisticated and formalized among musical systems of the world [Sambamoorthy 1994]. The perception of music as a pure melodic exposition in tune with the composer's imagination contrasts the harmonic style used in Western Music [McComb 1999; Todd 1989]. In Carnatic music, the performer has the liberty to express his welling musical thoughts. This emphasis on creativity is its distinctive feature, called "*Manodharma Sangita*," music dynamically created out of fertile imagination of a musician [Panchapakesa Iyer 1986].

In a typical Carnatic music performance, these creative elements are rendered in the form of Alapana, Kalpana Swara, Neraval, Thaanam, etc. The creativity of the performer is manifest in his method of maneuvering the notes within a given set of melody constraints [Panchapakesa Iyer 1986]. The analysis of the note sequences employed by the performer is done using a set of pattern classes. Based on the formalizations of Carnatic musicology and our own observations of performances, a basic set of pattern classes have been defined by the authors. It is also seen that creative note sequences can associate themselves to more than one class of patterns to

varying degrees, and hence involving a non-crisp fuzzy relation. The inherent inclination of a particular performer to employ various pattern classes to different extents is assimilated. This evaluation of performer's creativity can be used in Style-based musical generation.

Notation

In the Carnatic music system, as in most others, the twelve note octave quantification holds. However, the nomenclature of the notes in the Carnatic system is different from that of the western system [Sambamoorthy 1994]. To make clear our representation of the notes as symbols, we have provided a mapping of these systems' nomenclature.

South Indian	Short	Symbol	Western
Shadjam	S	1	C
Sudha Rishabam	R1	2	D Flat
Chatusruthi Rishabam / Sudha Gandharam	R2 / G1	3	D Natural/ E Double Flat
Shatsruthi Rishabam / Sadharana Gandharam	R3 / G2	4	D Sharp / E Flat
Antara Gandharam	G3	5	E Natural
Sudha Madhyamam	M1	6	F Natural
Prathi Madhyamam	M2	7	F Sharp
Panchamam	P	8	G
Sudha Dhaivatam	D1	9	A Flat
Chatusruthi Dhaivatam / Sudha Nishadam	D2 / N1	10	A Natural/ B Double Flat
Shatsruthi Dhaivatam / Kaisiki Nishadam	D3 / N2	11	A Sharp / B Flat
Kakali Nishadam	N3	12	B Natural

Table 1: Symbolic representation of notes

Pattern Classes

Enumeration of pattern classes for our proposed system

A pattern is defined as a set of ordered elements. Our system needs to classify sequences in a more generalized method, rather than as specific set of discrete sequences. For example, one could not gain much by defining the pattern $\{1, 2, 3\}$, as occurrences of $\{3, 4, 5\}$ would not count as the same pattern. A more general representation encompassing both the above patterns would be $\{x, x+1, x+2\}$, where x is any arbitrary note.

In line with our requirements for a more general classification of sequences, we consider Pattern Classes. A Pattern Class can be expressed as a class which contains pattern of the form *{sequence <belongs to> value set}*. By value set we mean the allowable note sequences in a particular Pattern Class.

It turns out that note sequences employed by the performer in a particular performance belong to a set of pattern classes. Thus, rather than a one – to – one association of a sequence to a pattern class, it is appropriate to associate a sequence in terms of 'degree' of membership to each of the classes. The membership of a sequence to a pattern class can be interpreted as a degree of certainty to which a sequence belongs to a particular pattern class.

In the following, we have enumerated a set of basic pattern classes based on the Carnatic Music theory [Panchapakesa Iyer 1986].

No.	Name	Pattern Class
1	Swaravali (Sarali)	1234…8(asc) 8765 …1(desc)
2	Jandai	111111…11
3	Dhattu	1323 2434 3545 … 6878 8676 …… 5343 4232 3121
4	Udhvahita	1232 2343 3454 … 6787 8767 … 5434 4323 3212
5	Hladhamana	1432 2543 3654 ... 5876 8567 …… 6345 5234 4123
6	Uthkadhita	12 543 23 654 … 45 876 87 456 76 345 … 54 123
7	Bindhu	1112 2223 3334 … 7778 8887 7776 6665 … 2221
8	Trivarna	12 333 23 444 … 67 888 87 666 … 43 222 32 111
9	Hasitha	1 22 333 4444 … 88888888 88888888 … 4444 333 22 1

Table 2: Example Pattern Classes defined based on Carnatic musicology

Although this enumeration represents most common pattern classes that have been formalized, more classes can be evolved. Enrichment of the existing library of classes can be through more detailed classes / subclasses or class extensions as dictated by the performers' creativity. These extensions and dynamic new classes widen the scope of evaluation of a performer.

System Architecture

The analysis of note sequences focuses on the creative elements in the contexts of a Carnatic music concert. A note sequence is taken as an input token to the system. The system measures its degree of attribution to each of the classes. The domain of the degrees of attribution is the rational number set between 0 and 1.

When a sequence has no attribution to any of the available pattern classes the scope of the existing library of pattern classes needs to be widened. A non-attributed sequence, which occurs frequently, is generalized to form a new pattern class.

The processes and the data interactions involved are elucidated in the system architecture. Figure 1 gives a view of this architecture.
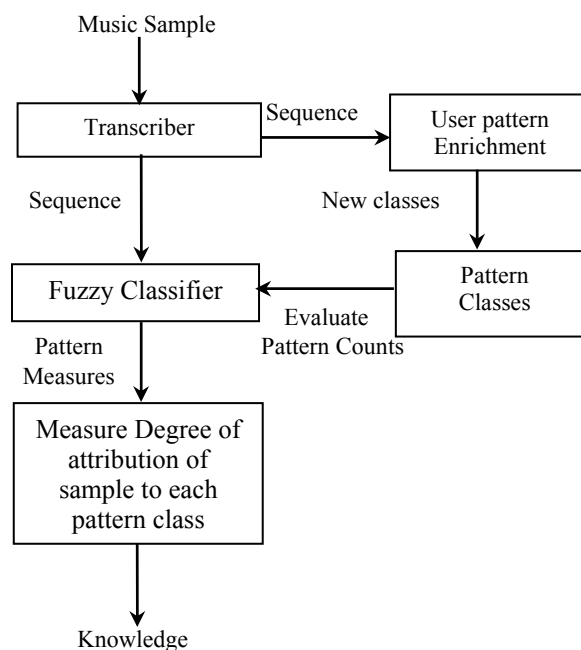
System Block Diagram

Figure 1: Block diagram of the system

Basic Process Units involved in this System

Transcriber: The transcriber reads the musical sample in a wave format and converts them to note format saved in a file that can be processed further. The transcriber outputs the note sequences.

Pattern Classes: The pattern classes that we have modeled form a library. The knowledge of a performer is to be quantified into sets, each set containing attributions of samples to the pattern classes. Each of these sets contains a template descriptor for an ordered symbol sequence. The cardinality of this set is the number of samples taken for this performer.

Fuzzy Classifier: The classifier is a process that compares the note sequence with the patterns in the class library. The note sequences are parsed to determine the presence of each of the pattern classes. The note sequences might resemble or satisfy the conditions of more than one class. We define an algorithmic module called membership function. All possible class matches in these note sequences are to be enumerated. A count of the matches to a particular class provides an individual quantitative measure. It is then processed further to obtain qualitative information.

Performer-based Pattern Enrichment: The classes we have modeled in this system cover most patterns. A performer might still exceed these limits and use some of his distinctive patterns. These can be incorporated for further enrichment of the system. The pattern enrichment process determines the distinct new patterns and updates the class library.

Update on Fuzzy Sets: Once the count of each pattern in a sample is known, we need to determine their degrees of belonging to each of these classes. The total number of patterns used dictates the effect of each of these patterns in this sample. We measure the degree of belonging to a class by a simple proportion. We calculate the ratio of the number of times a pattern occurs out of the total number of times all patterns occur. The degrees of each of these classes are appended to the fuzzy sets of the performer. This gives the knowledge output, which can be put into use effectively for various applications.

Functional Specification of the System

The system aims to capture the essence of the creative music expressions in a qualitative representation. The sequence of steps involved in this process is enumerated below.

1. Read the music sample in wave format
2. Convert these music samples into note format

3. The notes are saved as text, enumerating the sequence of notes.
4. The note sequence is parsed for fuzzy classification and for enrichment of pattern classes.
5. The sequences are parsed to determine the count and degree of belonging to different patterns. The sequence might contain more than one pattern and the patterns might be superimposed.
6. Then the system evaluates the number of times a pattern class is present in the sample.
7. An array of counts of the number of times the note patterns recur in the sample is determined.
8. The proportion of each pattern in the sample is determined by

   $$P(X) = N(X) / N(S)$$

   Where $N(S)$ is the number of pattern units recurring in the entire note sequence. $N(X)$ is the number of times the pattern for Class X has been repeated. $P(X)$ gives the proportion of the class X's occurrence in the entire sample. This value falls between 0 and 1.
9. The degrees $P(X)$ for each of the classes X in the class library is appended to the set for the Class X.
10. The knowledge represented in this form can be used to reproduce or generate patterns based on the weight of these classes in the Performers' samples.

Delineating further complex classes enrich the system further. We have the classes divided based upon more specific pattern usage. Matrices can replace the sets that we have used here if the length of the creative patterns can be considered as contributing to the creativity of these patterns. Thus each column of these matrices would now indicate the length of the notes employed in that pattern.

Illustration

In this section, we illustrate the entire process of the system as outlined above.

The heart of the system, the fuzzy classifier, parses the entire sequence. Whether a pattern occurs or not is determined by a descriptor or membership function. This is a rule, which imposes certain conditions for association. For example, for Jandai, the definition would be {x, x}. On detection of a pattern (Eg: {1,1}, it increments the hit count on that Jandai class. Further, both 11 and 444444 come under the {x, x} pattern class because, for each paired subsequence, both notes are the same.

Moreover, it is also important to note that a single subsequence could belong to more than one pattern class. Consider the following sequence.

33724165427658755554444333221

Close observation of the notes reveals that in the first part of the sequence, there is a Hladhamana pattern class.

33724 *1654 2765* 87 555554444333221

Although the occurrence does not match the exact value stored class library, it is a modified version of the pattern. Thus, in place of

{x, x+4, x+3, x+2}, {x, x+5, x+4, x+3}

can be used. In fact, it would be more general if we represented the membership function or condition as

{x, x+n, x+n-1, x+n-2, …}

It is also observable that the last part of the given sequence resembles both "Hasita," and "Swaravali(desc)" classes (however to varying degrees). In addition, the "Hasita" is superimposed on the descending "Swaravali". This also justifies our use of fuzziness.

In order to determine the measure of association to a pattern class, we again use a "degree of occurrence" based approach to the problem. In the above example, the first occurrence of 33 does not imply to a great extent that the performer employs Jandai (duplications) more frequently. These random notes would only contribute as noise. On parsing of the entire sequence, the hit of 33 as Jandai would have been eclipsed by other multiple hits on other patterns.

In this example, it is significant that the system does emphasize more on the occurrence of Hasita because of its fullness of occurrence. When compared with the previous

1654 2765

Hladhamana sequence, the Hasita sequence of

555554444333221

has been employed to a fuller extent. This means that out of the full set of

8888888877777776666665555544444333221

only a subset of this sequence is employed:

55555444433321.

Therefore, the degree of association of this subsequence to "Hasita" would be larger than that of 1654 2765 to "Hladhamana."

Future Work

We found that the inherent usage of patterns by the performer while rendering Kalpana Swara is attributed to his creativity. Hence by knowledge acquisition of patterns specific to a performer, the computer could aptly enact his style.

Music experts are often skeptical about music, which is autonomously composed by computers. We have proposed a system that captures the dynamics of the performance based on Carnatic musicology. The knowledge acquisition of our system will have a direct impact on the music composition process with specific style (style based music generation). Style in the context of a musical performance is an implicit aspect ascribed to a performer that cannot be consciously manipulated; however possesses quantifiable and distinctive features.

The knowledge assimilated through this system has applications in the fields of authorship identification, stylometry and learning.

References

Krishnaswamy, A., 2003. *Application of Pitch Tracking To South Indian Classical Music.* In the Proceedings of the International Conference on Acoustics, Apeech and Signal Processing, Hong Kong, China: IEEE Inc.

Panchapakesan, A.S., eds. 1986. *Karnataka Sangitha Sashtram.* Chennai: Ponolli Offset Press.

Todd, P. M. 1989. A connectionist approach to algorithmic composition. *Computer Music Journal* 13: 4-4.

Sambamurthy, P. eds. 1994. *South Indian Music Volume 4.* The Indian Music Publishing House, Chennai, India.

Duda, R.O., P.E. Hart, and D.G. Stork, Pattern Classification. Second ed. 2001: John Wiley and Sons.

Ramakrishnan M.S., Devanathan R, Palaniappan C.T., and Ganesh Ram S. 2003. A New Approach to Machine Cognition of Music using Carnatic Music Ideology. In the proceedings of the Eleventh International Conference on Advanced Computing and Communications, 39, Coimbatore, India: Advanced Computing and Communications Society Inc.