RESEARCH ARTICLE OPEN ACCESS

Basic Pattern Generation for Kalpana Swara Synthesis Using Graphical Approach

Mahesha Padyana [1], Bindu A Thomas [2]
Department of Electronics and Communication
Vidya Vikas Institute of Engineering and Technology
Mysore – 570 028
India.

ABSTRACT

There are several types of music in this world based on the region and other factors. Carnatic classical is one kind of music having its own speciality and found commonly in southern parts of India. Carnatic classical is characterized mainly by improvisation and ornamentation. Carnatic classical music contains lot of physics and mathematical parts [4]. "Creative Music", which is the hallmark of Carnatic classical (also known as manodharma sangeetha or improvisational music) means, presenting as per the wish of the musician depending on the time, mood and many other aspects. Creative music comes out spontaneously without memorizing, but within the boundary of raaga and also adhering to the rules. Some form of creative music is also bound by thaala. There are several types of creative music in Carnatic classical. One of them being is called kalpana swara. Kalpana swara is one of the most complex forms of manodharma sangeetha because of its restrictions on ending, thaala boundary and integrity of raaga structure. The syllables of music should end smoothly at same point in the thaala cycle. In this type of music, lot of patterns of swaras will be weaved within the boundary of raaga, thaala and laya (or tempo) of sangeetha to give pleasing and soothing effect. This paper gives various algorithms used for generating basic patterns for the kalpana swara. These basic patterns are widely used while constructing the kalpana swara.

Keywords :- Indian classical music, Carnatic music, creative music, kalpana swara, manodharma, music patterns, thaala, tala, raaga, raga, graph theory, algorithm, Markov chain.

I. INTRODUCTION

The basic elements of Carnatic music are "Shruthi", "Swara", "Raaga" and "Thaala". The pitch of a musical sound is determined mainly by its frequency and is a measure of how "high" or "low" a tone is, and is measured in hertz (Hz) [9]. The most basic unit of Carnatic music is the shruthi, which indicates a position in the audible spectrum occupied by a particular sound. It is also referred as swara sthaana and can be considered as the smallest interval of pitch that the human ear can detect. In classical music, various swara sthaana are identified by seven swaras (or notes or sol-fa syllables) and their variants.

Thaala is a repeating rhythmic pattern used to synchronize the music. Thaala repeats with same tempo (or speed) in a specific pattern. One of such repeating pattern of thaala is called as an aavartha. Thaala is played by hand or using percussion instruments. Most of the Indian classical music is strictly bound by thaala.

Raaga in Indian classical music is one of the melodic modes of the music. It is similar to a scale and it is composed of five or more swara arranged in a specific manner. Selected swaras are framed in ascending order called aarohana and descending order called avarohana depending on the requirement of the music. In some raagas, the notes may not be in proper order of ascending or descending. Raaga is also characterized by special sequence of swaras called ranjaka swaras and various swara flow called sanchara.

Kalpana swara is the method of weaving swaras in various patterns around chosen line of lyric called kalpana swara phrase [2]. In kalpana swara, musician comes back to kalpana swara phrase again and again after weaving set of swaras of the raaga. Weaved swaras followed by kalpana swara phrase is called as one aavartha of kalpana swara. The artist will present several aavarthas of kalpana swara with various combinations of swaras applicable to the chosen raaga. During the process, artist has to maintain the integrity of the raaga and also the thaala and laya. Kalpana swara generation requires lot of patterns to be generated. Pattern generation is broadly classified into basic pattern generation, yathi pattern generation, linking patterns and concluding patterns. Basic patterns form the foundation for generating other patterns.

II. LITERATURE SURVEY

There are few applications available for generating music. Gaayaka software enables us to enter syllables of the raaga (called as swaras) such as "S R G M" play it with flute or veena as instruments. It is useful for experimenting or practicing carnatic music lessons in one's own shruthi. Lessons up to geethams and sample krithis, varnams etc. are supplied with the software. User can enter and play even lessons not supplied with the program. The notation system has been extended to enable introduction of smooth gamakams. Gaayaka can be an aid for experimenting, understanding the nuances and setting songs to notation, making it easy to check the durations and the tune.

Sishya gives lessons in a user friendly format with pictures showing the thaala gestures synchronized with the music. JRaaga is another application that can generate carnatic music lessons for all 72 melakartha raagas and raagas with 6 or 7 notes in their aarohana/avarohana - for any thaala/jaathi combinations.

P Sambamoorthy[1][2][3] wrote six books on carnatic music. He explained several aspects of carnatic classical, thaala system, gamaka and improvisational music. Author specified several rules for presenting Kalpana Swara. These books have been extensively referred for developing this paper.

Cormack and Josepha Anne et.al [6] comprehensively documented the improvisation music of carnatic classical. Authors elaborated the application of kalpana swara in concerts, general construction of kalpana swara, aspects of handling the problems associated with rhythms and melody. They interviewed renowned carnatic classical musicians and documented their views on kalpana swara in general. They also included the graphs showing distribution of amsha and graha swaras in kalpana swara presentation. According to them, initial phrases in kalpana swara need not use vishesha prayogas. The gamakam is skipped in fast tempo kalpana swara phrases. If raaga has less scope for aalaapana or has more jumps in aarohana or avarohana, the scope for kalpana swara is less.

M.Subramanian[11] explained the method for producing the computer music digitally instead of analog means. He started his paper by indicating the problems encountered with computerization of carnatic classical. The problems that he lists are the problems in recognizing notations for gamaka and bhaava, extemporization harmony with percussion accompaniments etc. He had tried to generate carnatic music on the computer with gamakam closely approximating to the natural singing. The first program was producing music in the tones of veena and flute while the second one enabled generation of synthetic music by entering notation in the traditional 'sa ri ga ma' style. He presented various problems arising in music synthesis.

III. TECHNOLOGY

There are various types of basic patterns. The kalpana swara synthesizer could make use of basic patterns and linking patterns to generate set of complex patterns. Basic patterns are generated first. Basic patterns will also consider stretching the swara and also pauses randomly so that the beauty of the presentation is increased.

The technology followed in the generation of basic patterns is the concepts of graph theory. A graph is a diagrammatic representation in which circles or nodes called vertices are connected by some lines or arc called edges. According to graph theory a graph G(V, E), is defined as an ordered pair of two sets V- the set of vertices and E- the set of edges. An edge is the ordered or unordered pair of its end vertices. Graph traversal is the method of visiting the vertices in a graph in a particular manner, updating and/or checking their values along the way. The graph in which, edges having unordered pair of vertices has no preference in the direction of traversal, i.e. traversing is possible in both direction across the same edge. Such graphs are called undirected graphs. But in the other case, edges having ordered pair of vertices, the allowed direction of traversal is only from first vertex to second vertex, such graphs are called directed graphs, e.g. consider a directed graph Fig. 1 with four vertices S, R, G, M and edges e1=(S, R), e2=(R, G), e3=(G,M) and e4=(R, S),. Here e1 and e4 have same end vertices, S and R, but e1 represents the direction of traversal from S to R and e4 is from R to S.

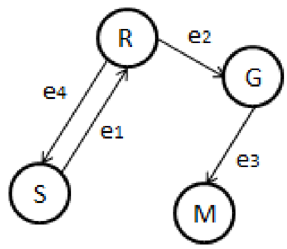

Fig. 1 Directed graph

The concept of graph theory is applied in Carnatic music to generate raaga graph. Raaga graph is the graphical representation of a raga and it is a directed graph. Patterns are generated based on the flow of aarohana and avarohana of the raaga. Various algorithms are used to generate basic patterns within the boundary of raaga and every pattern generation algorithms may make use of this raaga graph for the generation of patterns. The pattern generating algorithm will never violate the raaga, since raaga graph is generated considering every rule of the raaga.

Each algorithm needs inputs for generating patterns and these inputs may be generated randomly. The randomly generated inputs would be the combination of one or more swaras in aarohana or avarohana, which has to be converted to combination of vertices to follow graphical approach. Based on the requirements, a reference pattern is generated and the final result is synthesized based on that reference pattern.

In graph theory, every data and flow of data of a graph are handled using the vertex set and edge set. The vertex set and edge set of a raaga graph is derived from aarohana and avarohana of that raaga. Every raaga have a raaga graph and each have unique characteristic.

Creation of raaga graph mainly implies the creation of two sets, vertex set and edge set, e.g. consider the raaga Reethigowla with aarohana: S1 G2 R2 G2 M1 N2 D2 M1 N2 N2 S1' and avarohana: S1' N2 D2 M1 G2 M1 P1 M1 G2 R2 S1. The vertex set (Vreal) of its raaga graph, will have the collection of vertices which represents all the swaras in both aarohana and avarohana. The vertices for the repeating swaras are grouped and treated as a single vertex to form Vgrouped in the graphical representation. Even if it is represented as single vertex, it will have the details of each vertex which contributed for its formation. For illustration we are considering only the base octave here, i.e. Vreal={S1, G2, R2,G2, M1, N2, D2, M1, N2, N2, S1', S1', N2 , D2, M1, G2, M1, P1, M1, G2, R2, S1} and edge set include the ordered pair of all the vertices representing the adjacent swaras in the aarohana and avarohana, i.e. E={(S1, G2) , (G2, R2), (R2,G2), (G2, M1), (M1, N2), (N2, D2), (D2, M1), (M1, N2), (N2, N2), (N2, S1'), (S1',N2), (N2, D2), (D2, M1), (M1, G2), (G2, M1), (M1, P1), (P1, M1), (M1, G2), (G2, R2), (R2,S1)}. In graphical representation the repeating vertices are grouped to form a vertex set Vgrouped= {S1, G2, R2, M1, N2, D2, S1', P1}. The graphical representation is given in Fig. 2.

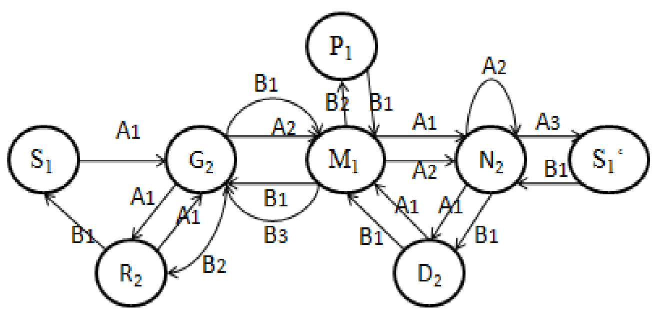

Fig. 2 Raaga Graph of Reethigowla raaga.

The tags A and B are used to differentiate between the edges formed from aarohana and avarohana respectively. In raaga some swaras are repeated more than once, e.g. here the swara G2 repeats four times. But all these swaras are combined together to form a single vertex. The number associated with each edge will specify the priority of traversal from current vertex. Priority is defined by its occurrence in aarohana/ avarohana. Let us consider the vertex G2, it have four outgoing edges A1, A2, B1 and B2. The next vertex for basic pattern generation is chosen based on, aarohana or avarohana or random pattern. In aarohana and avarohana, next vertex is the adjacent one which comes in the same order as in aarohana and avarohana of the raga. In random case, the next vertex is chosen randomly from the list of all adjacent vertices or considering the priority. If the vertex is associated with a priority value then priority is considered in choosing next vertex, the smallest value have higher priority. Else randomly choose any from the list of outgoing vertices, in such case moving from aarohana to avarohana may happen during traversal. The pattern generating methods shall make use of these traversal methods to generate the patterns.

The basic pattern generation follows the outline represented in Fig. 3.

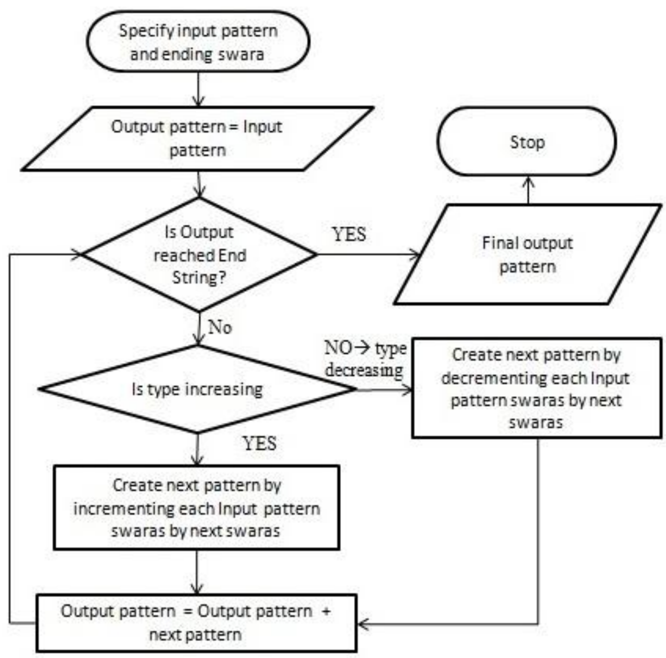

Fig. 3 Flowchart representation for basic pattern generation.

IV. PATTERN FOLLOWER

Pattern follower is a powerful pattern generating module. Pattern follower will generate patterns that follow the input pattern until the end condition is reached. In case of pattern follower, a reference input pattern and end swara will be provided to the module. This method caters for many types of pattern creation. There are two types in this module, one for aarohana and the other for avarohana. In case of aarohana type, patterns will be generated making use the swaras from aarohana pool only and in case of avarohana, swaras belonging to avarohana pool will be used. Depending on the input pattern and end condition, patterns can be type increasing and type decreasing. Type increasing means pattern follower has to traverse forward to reach the end condition and in case of type decreasing pattern follower has to traverse backward.

Patten follower algorithm will have parameters such as, input pattern (reference pattern), end condition. The end condition can be an end pattern or length of the pattern. Reference pattern is the one from which the pattern generation starts, and it is a sequence of one or more vertices. Each successive pattern will follow the reference pattern until it reaches end condition.Few examples of pattern follower are given in TABLE 1.

TABLE 1 Pattern Follower Examples

Type	Input pattern	End Swara	Patterns Expected	Number of Patterns
Aarohana incrementing	SR	M	SR RG GM	3
Aarohana decrementing	SRG	N.	SRG N.SR, D.N.S P.D.N.	4
Avarohana incrementing	MGR	P	MGR PMG DPM NDP	4
Avarohana decrementing	MRS	N.	MRS GSN.	2

The pattern generation algorithm for pattern follower is explained in the flowchart Fig. 4.

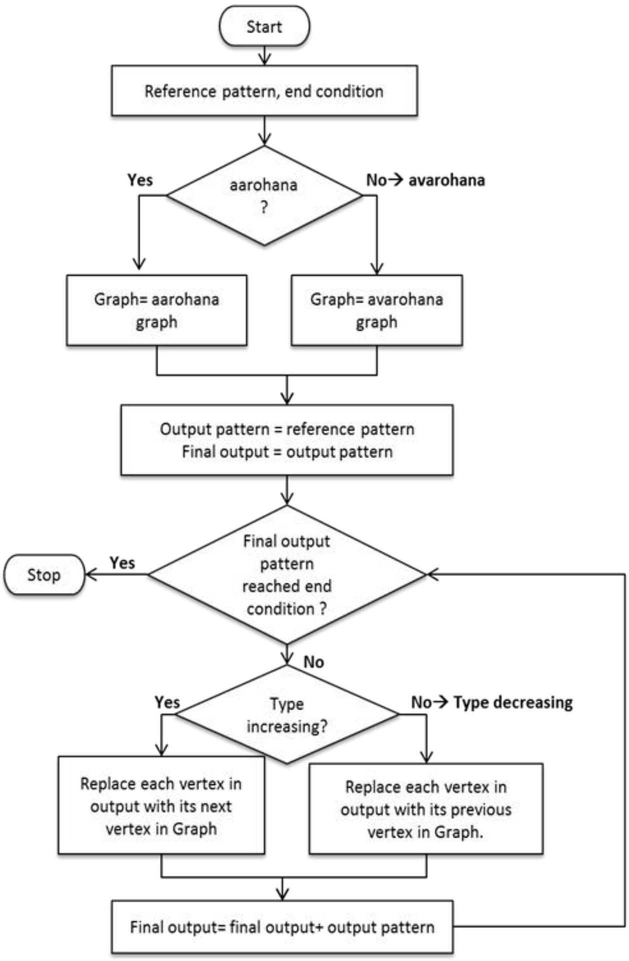

Fig. 4 Flowchart for Pattern follower.

V. LINKING PATTERN

Linking patterns are the patterns generated for joining two distinct patterns. Linking patterns are mainly used to join two basic patterns or to join a basic pattern with any other kalpana swara phrase. Linking patterns are usually random patterns. Linking pattern algorithm will have parameters such as, input pattern (start vertex), end vertex and length. The start vertex and end vertex depends on the two patterns which it is going to combine. The start vertex is the next vertex of the first pattern, end vertex is the previous vertex of second pattern/ kalpana swara phrase and length is the size of linking pattern required. The linking pattern will start from start vertex and follow a random walk on the graph to reach the end vertex. Ultimately linking pattern algorithm is following Markov chain concept for generating the pattern. In Markov process next state depends only on the current state and not on the events preceded it. In the case of linking pattern generation next vertex is generated randomly based on current vertex position in the graph. The linking pattern algorithm is explained in the flowchart Fig. 5.

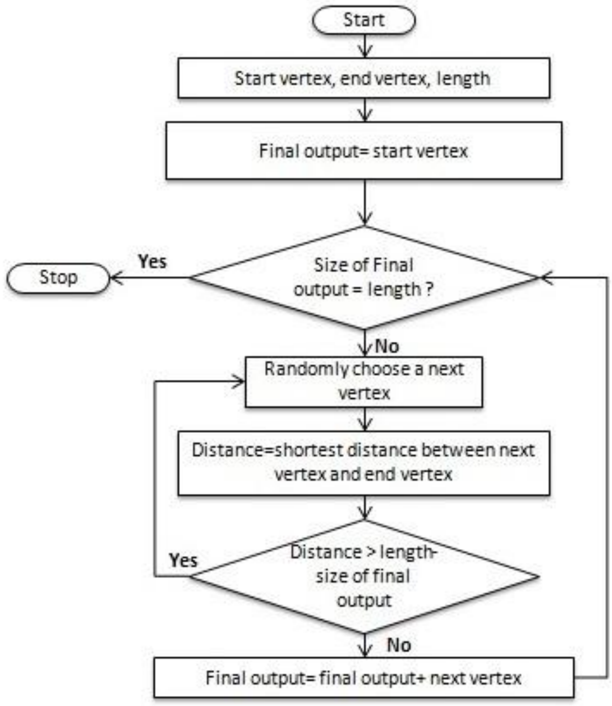

Fig. 5 Flowchart for linking pattern generation.

VI. RESULTS

The software generated outputs are given below.

A. *Pattern follower*

Inputs: Reference pattern: S N. D.End condition: D and Type: aarohana

Output: S1 N3. D1.
R1 S1 N3.
G3 R1 S1
M1 G3 R1
P1 M1 G3
D1 P1 M1
N3 D1 P1
S1' N3 D1

B. *Linking pattern*

Inputs: Reference pattern: S End condition: N and length:110.

Output: S1 R1 G3 R1 G3 M1 P1 D1 P1 D1 P1 M1 G3 M1 G3 R1 S1 N3. S1 R1 G3 R1 G3 M1 P1 D1 N3 D1 N3 S1' R1' S1' R1' S1' R1' S1' R1' G3' R1' S1' R1' S1' R1' S1' N3 D1 N3 S1' R1' G3' M1' G3' R1' S1' N3 D1 N3 S1' N3 D1 N3 D1 N3 D1 P1 D1 P1 M1 G3 R1 G3 M1 P1 M1 P1, M1 P1 D1 N3 S1' N3 D1 N3 S1' N3 S1' R1' G3' R1' G3' R1' G3' R1' G3' R1' G3' M1' G3' M1' G3' R1' S1' R1' S1' N3 D1 N3 D1 N3

VII. CONCLUSION

Basic patterns with the algorithm specified above gave expected results. The algorithm was developed using java programming language with the help of a music library. These patterns could be utilized further in developing kalpana swara. This forms the foundation for synthesizing using software.

REFERENCES

[1] Prof P Sambamoorthy, *South Indian Music*, Book III, The Indian music publishing house
[2] Prof P Sambamoorthy, *South Indian Music* Book IV, The Indian music publishing house
[3] Prof P Sambamoorthy, *South Indian Music*, Book V, The Indian music publishing house
[4] *The mathematical basis of Raaga Prasthaara (Carnatic system)*, K. Ramachandra
[5] *Mathematical basic of the thaala system, Carnatic music*, K. Ramachandran
[6] Cormack, Josepha Anne,"Svara kalpana Melodic and rhythmic improvisation in Karnatik music", PhD thesis Wesleyan University, 1992
[7] Musical treatise Ragavardini explaining various aspects of Manodharma Sangeetha.
[8] C.S.Ayyar "The Grammar of South Indian (Karnatic) Music", 1951, pp 138-140
[9] C.S.Ayyar "Microtonal Variations in Frequencies in Karnatic Music –II", Current Science, Feb.,1953, 22, 39-40.
[10] BRC Iyengar "Kalapramanam in kriti-s", Shruthi Journal P39 January 2009
[11] M.Subramanian *"Synthesizing Carnatic Music with a Computer" Journal of Sangeet Natak Akademi, New Delhi, India*, No's 133,134, 1999, pp 16-24.
[12] M.Subramanian, *"Carnatic Music: Automatic Computer Synthesis of Gamakams", Sangeet Natak',Vol. XLIII*, Nov., 2009
[13] Software applications Gayaka and Rasika available at http://carnatic2000.tripod.com/
[14] Jraaga application available at https://sourceforge.net/projects/carnaticmusicguru/files/