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Carnatic Music - Automatic Computer Synthesis of Gamakams

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1. Introduction: With the advent of affordable personal computers it is possible to generate synthetic music from notation. Many programs to generate synthetic music are available (mostly oriented towards western music and polyphony). Developing a system for synthesising Carnatic music with a computer has some special requirements [Ref 1]. Such a system would require the capability of smooth transition between notes maintaining tonal quality with controllable transit time and preferably ability to minutely vary the frequencies of the notes. Such a system was developed by this author as a part of the software Rasika-Gaayaka in 1998 and has been further improved [Ref 2].

1.2 In the Gaayaka program it is possible to type the notation in the traditional 'sa ri ga ma..' fashion and play it in the tones of Veena or Flute at the required tempo and adhara sruthi. However, Gaayaka or any other program would play exactly what is entered. The simple notation as usually written for Carnatic music compositions does not include the gamakams or nuances. Such notation when played would often be unrecognizable especially when the gamakam spans a large range of pitch. Simple notation may be passable for some songs in fast tempo or in simple note based ragams. In most cases the simple notation has to be rewritten for the computer to play the nuances correctly. The Gaayaka program gives some ready made notation for the nuances for some common ragams, which could be copied and pasted where required. This however required considerable effort by the user and correct interpretation of the melody that he wants to reproduce. The Gaayaka program included a number of songs as examples for writing notation in detail with nuances and these songs came quite close to the usual way of singing them. Still writing detailed notation to reproduce the nuances correctly is quite difficult.

1.3 A website using a Java Applet is available where it is possible to graphically indicate the pitch movement for the gamakam and play it through the MIDI device or save as a MIDI file [Ref 6]. In this case also the user has to have a precise idea of the range and durations of the movement of the pitch.

1.4 This paper describes the results of the author's effort to develop a computer program to automatically generate nuance based notation from simple notation, explaining the issues involved, the strategies used and the residual manual effort still required to generate a final acceptable version from the skeletal notation.

2. Carnatic Music and notation

2. 1 Gamakam: The term 'Gamakam' , though historically defined as shaking of a note (in works like Sangeeta Ratnakaram), is now used in Carnatic Music to indicate all movements between and around notes. A gamakam may be a short range oscillation 'within' a note or an oscillation spanning even 3 semitones. Slides from note to note ('jaaru') and crushed notes (as in the case of pairs of the same note - 'janta') are also classified as gamakams. The notes not explicitly used in notation are called ‘answarams’.

2. 2 Carnatic music is heavily phrase oriented. Notes are more often held with gamakam than as straight notes. [Ref 3]. The manner in which the notes are sung characterises the ragam and makes it easy to portray or recognise the ragam with only a few phrases.

2.3 Published notation: Carnatic music also has a large number of compositions which form the basis of concerts. With the advent of printing, notated compositions of famous composers were published as early as in the middle of the nineteenth century. However, the notation is skeletal and except for a few publications like the 'Sangeetha Sampradaya Pradarsini' by Subbarama Deekshithar (1905) [Ref 4] no indication is given about the manner in which the notes are to be sung. Even the symbols used in Sampradaya Pradarsini gives only a general qualitative description of the nuance. More recently the publication “Sangeetha Svararaga Sudha“ by Akella Mallikarjuna Sharma [Ref 5] gives graphic type of symbols for gamakams. Even without any symbols for gamakams a musician who has a good grasp of the nuances of a ragam can sing a kriti from the notation, filling in for the nuances. In spite of the easy availability of recording systems, songs with notation continue to be published and are in demand.

3. Automatic generation of gamakam: The possibility of developing a computer program for automatically generating the appropriate gamakam from skeletal notation was examined and a system which can be called the first stage in this process has been developed. The primary use of such a system would be to generate acceptable music for old notations for which no physical recordings are available. Though the absence of gamakam in the published notation is the main drawback, there are a few other aspects in the notation which also require correction. The process for insertion of gamakams is discussed first below.

3. 1. Possible approaches: While it would be possible to generate the gamakam by inserting the detailed notation in the background without altering the skeletal notation, such an approach will prevent the user from making further finer changes, or (as explained later) when more than one alternative is possible, to choose the alternative considered best by the user. Consequently the program designed generated entirely new detailed notation with detailed notation which can be played by the Gaayaka program.

3.2 Phrase oriented approach: Basically two approaches are possible. The ideal would be to look for phrases in the notation and have them replaced by detailed notation incorporating the nuances, selected from a database for that ragam. This would result in the synthesized music to

be very close to the sung. But since the durations of the notes within a phrase would influence the final outcome and the number of notes in a phrase could also vary, an unmanageably large number of phrases would have to be provided in the database for each ragam.

3.3 Note oriented approach: The other approach would be to replace a note with a detailed notation (which may include other notes or anuswarams touched in the gamakam) for the duration of the note. If we consider a phrase as combination of notes and take into account the duration of each note and the context in which the note appears in the phrase, then applying gamakam to the individual notes could also give a result quite close to the one possible with phrases This would imply a more manageable database containing detailed notation which takes care of both the aspects viz., duration and context within a phrase for a single note. The program will have to choose from the database the appropriate notation based on the duration and context and also ensure that the total duration is kept unchanged. This is the approach used in the current project and is described below.

3.4 Requirements for the ragam database: The characteristic gamakam applied to a note in a particular ragam, depends upon the (a) duration of the note and (b) the context in which it occurs. 'Context' here describes whether the note occurs in the ascent or descent or there is a turning on the note - again in the ascent or descent or the note follows or precedes the same note, or is preceded or followed by silence etc.. A database for each ragam has to be built up for being used as the basis to generate the detailed notation A single database for a Melam (scale) would not suffice as notes in the janya ragams (ragams classified under that scale) are often held differently from the parent ragam and each ragam has its own special nuances (as for instance, in the case of Arabhi, Bilahari, Begada janyams of Dheerasankarabharanam)

3.5 Duration of note: The duration is very important since shorter notes tend to have less number of oscillations instead of faster oscillations. Very short notes could be played without gamakam. For instance in the ragam Kaanada a detailed notatoin for the note 'ga' lasting for about a second would show 2 oscillations and then ending in 'ma' before the next note is sung, whereas 'ga' lasting half a second could have a single oscillation and when sung for 0.15 secods or less could even be a plain note (though connected to the other notes).

3.6 Duration ranges and adjusting duration: As regards duration, notes could have different lengths like 1,2,3,4 or even fractional like quarter, half, 1.5 etc. As no absolute tempo is prescribed in Carnatic Music, the actual duration of a note would depend upon the unit time chosen by the singer to sing a single note. Often the same notation could be written with note lengths doubled, which would only imply that the single note duration is reduced. Thus theoretically notes could have a wide range of durations, starting from about a tenth of a second to even 2 seconds or more and can have any arbitrary value in between such as 0.25, 0.32, 1.25 etc. (Gaayaka allows note durations to be fixed in units of 1/100th of a second). It would be unmanageable to define detailed notation for each individual duration. Therefore it was felt that the detailed notatons could be defined for different ranges of durations and 5 different ranges have been adopted in the program. Practical experience could show whether this number needs increase.

3.7 Context: The context of occurrence heavily influences the gamakam..To start with sixteen

different contexts have been defined for each note (ri, ga, ma, da, ni and in special cases for sa and pa also). These are more easily defined by symbols indicating whether the previous note is higher or lower or is the same or it preceded by or followed by silence. Another symbol could define the same details for the succeeding note. In addition the position of the note in the phrase would be useful - whether it occurs in the beginning or in the middle or at the end. Even more detailed approaches such as the duration of previous note or succeeding note, the notes occurring beyond the previous and succeeding notes etc. As an initial attempt 16 contexts have been defined.

3.8 For each context detailed notation has to be maintained in the data base for each duration range for each note, the database thus has a minimum of 400 definitions The data base can be simplified by not giving any definition for notes which in a particular ragam are always held straight (except in the case of Janta prayogams) and making the software leave the note unaltered if there is no definition in the database. Similar approach is possible for notes of very short duration.

3.9 More refinements: While this context definition based on direction of the pitch flow would be adequate in most cases , the actual note preceding or succeeding is also significant. For instance in the ragam Kambodhi, 'da' in the ascent will be held without gamakam in the phrase 'pa da ni da' while it is held with the gamakam called 'nokku' in the phrase 'pa da Sa'. Sometimes the position of the note in a phrase (start, middle or end) could also influence the manner in which it is sung. The software has to take care of such cases also. Thus additional gamakam notations will be required for specific succeeding note or preceding note or occasionally the position of the note in the phrase would also require separate gamakam definitions.

3.10 As the actual duration would depend upon the note length in the notation and the unit time adopted, it would not be possible for the database to give the final detailed notation as such for the wide variety of actual durations possible. . The database can contain definitions which are reduced to unit length and the software can expand it to the required note length before replacing the note. The Gaayaka program itself provides for fixing duration of the unit note with the accuracy of 0.01 second. The final notation should play correctly if the unit duration (given by the user in Gaayaka) is also an input to the program (for fixing the duration ranges).

4 Current stage of development: All the above requirements have been taken care of in the currently developed software and database for a few raagams. A few Varnams and Kritis were converted using the database and the results were examined.

4.1 Results - Varnams and Krithis: The experience showes that the auto insertion of gamakams is results in more accurate rendering for varnams than kirthis. Varnam is a musical form meant to epitomise the raga structure and is taught before the teaching of krithis and they are often sung in concerts as the first item. While teaching a varnam the notation is first taught. The lyrics of varnams have very few consonants (especially in 'taana varnams') and the singing of the lyric gives considerable training in singing 'akaara'. As the singing of the lyric is totally

based on the notation the music generated from notation converted by the computer sounds realistic. Also the versions of different artists are quite close to each other.

4.2 On the other hand krithis do not seem to have been composed with the notation in mind, which would explain greater variations in rendering by different artists. Actually the krithis have different tempos occurring within a single line and it would even be difficult to sing the notation consistently. The krithis are rarely taught (at least to vocal music students) with notation first. Notation is written down just as a guide to remembering the basic outline of the piece. Consequently the auto insertion of gamakam by the program is not always found to be fully satisfactory in the case of krithis, though sounding much closer to the required rendering than the bare notation.

4.3 The database is now being built up entirely manually using the author's experience as a Veena player, using some tools to analyze live music and playing the converted notation to refine the database. Conceptually it would be possible to built a database entirely based on computer analysis of live music using neural network techniques.

5. Other issues: There are many issues which arise when an attempt is made to mechanise what is really an art form.

5.1 More than one alternative: No single rendition of a phrase would satisfy everyone. For instance the madhyamam in the phrase 'ga maa paa' of Sankarabharanam could be held in at least 3 different ways. In some contexts all the 3 would be acceptable. Differences could arise due to the differences in styles of different schools. The same artist may sing the phrase differently on different occasions! In the current project wherever many renditions are possible, two alternatives considered as most appropriate are given in the database and the program shows both in the revised notation but 'comments out' the second one and marks the first alternative with a special symbol. This would enable the user to choose the alternative by suitable reediting. (Gaayaka itself would be revised for easy switching between alternatives)

5.2 Optional nuances: Some gamakams which are not absolutely necessary to portray the correct 'raga bhavam' are introduced by the singer according to his 'manodharma' to add beauty. Sometimes such refiements are shown in the notation but often left out. An example is the phrase 'sa ni da pa' in ragam Bhaiavi which could be sung descending from the note 'sa' normally but could also be held with a grace touching 'ri' briefly at the end of note 'sa' - sometimes indicated as 'saa, ri' with 2 linea on top (to indicate quarter notes) as illustrated below.

ṡa ni da pa **s̄aa, r̄i ni da pa**

Such graces (classified as 'orikkai') are often not indicated in the notation and it is left to the artist to add them if he considers it appropriate.

5.3 Indication for phrases: There is no accepted symbol for separating notes into phrases. In some books a "-" (hyphen) is used to separate phrases while in others it is used to show the 'aksharams' (time units) inside the Thalam framework. For a music to sound realistic, the notes are to be grouped into phrases. For medium paced songs, usually the consonants in the lyric

can be separation points for the phrases. For slow paced songs the phrase break has to come even inside a continuous vowel (especially for Veena) and this requires selection of an appropriate point. The need for separation of notes into phrases was considered in Gaayaka software and the hyphen symbol is used for this purpose. But since the notation in books often do not have any phrase separation symbol, this has to be added manually. While this can be done without much difficulty for fast paced compositions based on the words in the lyrics, it is extremely difficult to define a simple rule for breaking long vowel phrases into shorter ones and often different artists do it differently.

5.4 Areas of Silence: When a note ends at a point well before the end of the 'avartham' (rhythm cycle), it is held for some arbitrary duration and thereafter the singer is silent (though the rhythm accompaniment may continue) before he starts the lyric in the next rhythm cycle or the next point in the cycle. If silence is not added appropriately to the notation from books, the note would sound awkward when prolonged till the next rhythm cycle.

Another aspect of silence is the singing of consonant combinations in words like "Bhaktha", "Svaprakasa". Here there is holding of the breath by the singer at the point of double consonant and the words get split into phrases 'Bhak-tha' and 'Swap-rakasa' with a clear momentary silence in between. This is also faithfully reproduced on instruments (by stopping the vibrating string in Veena, the bowing in Violin or the blowing in the Flute). For the music to sound realistically this has to be reflected in the final gamakam notation. However, as it is linked to the lyric, for the present this has to be done only manually, especially since the notation given in books often lacks correct alignment between the notation and the lyric.

5.5 Approximations in rhythm: Although, the Carnatic Music notation system is reasonably accurate as far as the rhythm or temporal aspect is concerned, often some approximations are made, apparently to simplify the notation. For instance when a lyric starts at half an aksharam from the start of the rhythm cycle and the start of the lyric consists of 4 equal consonants (all 'hrsva') then the practice is to write notation for the first and third notes as single notes and second and fourth notes as double notes making up for the 6 units. Examples are "Sa-Saa-ni-daa" at the start of the krithi 'Gajavadana' when sung at an 'eduppu' of half aksharam. In reality it would be sung closer to "Saa,- Saa, -nee,-daa,-" (with a line above to show half notes) providing three fourths duration for each note. There could be a slight shortening of the first and third notes and lengtheing of the others, but certainly not as written. Similar spontaneous or extempore contraction of a full note into one of 3/4ths duration leaving 1/4th silence at the beginning of the aksharam is also common.

5.6 Evolving changes in rendering: Another problem noticed was that in the case of many krithis the rendering has changed in the course of time, but the old notation is still shown in the books. Computerised insertion of gamakam can only proceed on the bases of the outline notation provided and unless the outline is changed to reflect the present day rendering the final output may not sound familiar to listeners.

6. Future work: Some of these manual requirements could also be computerized using heuristic algorithms. Greater refinement of the context definition, more duration ranges etc. could make the converted notation more accurate. As mentioned earlier data can be generated

by computer analysis of live music also.

7. Other use for the data base: The conversion of live music into notation poses a challenge in Carnatic music, as most of the notes are held as oscillations over different range of pitches. A normal pitch extraction program relies upon concordance between the pitch found and the corresponding note, but in the case of oscillated notes this would be quite difficult. Even locating the start and end of a note in a continuous phrase would be difficult [Ref 3a]The data base developed for this project could help in better note identification from the pitch graphs.

8. Audio examples: Audio examples of music from bare notation and notation generated by the current program are available in the opening page of the website:

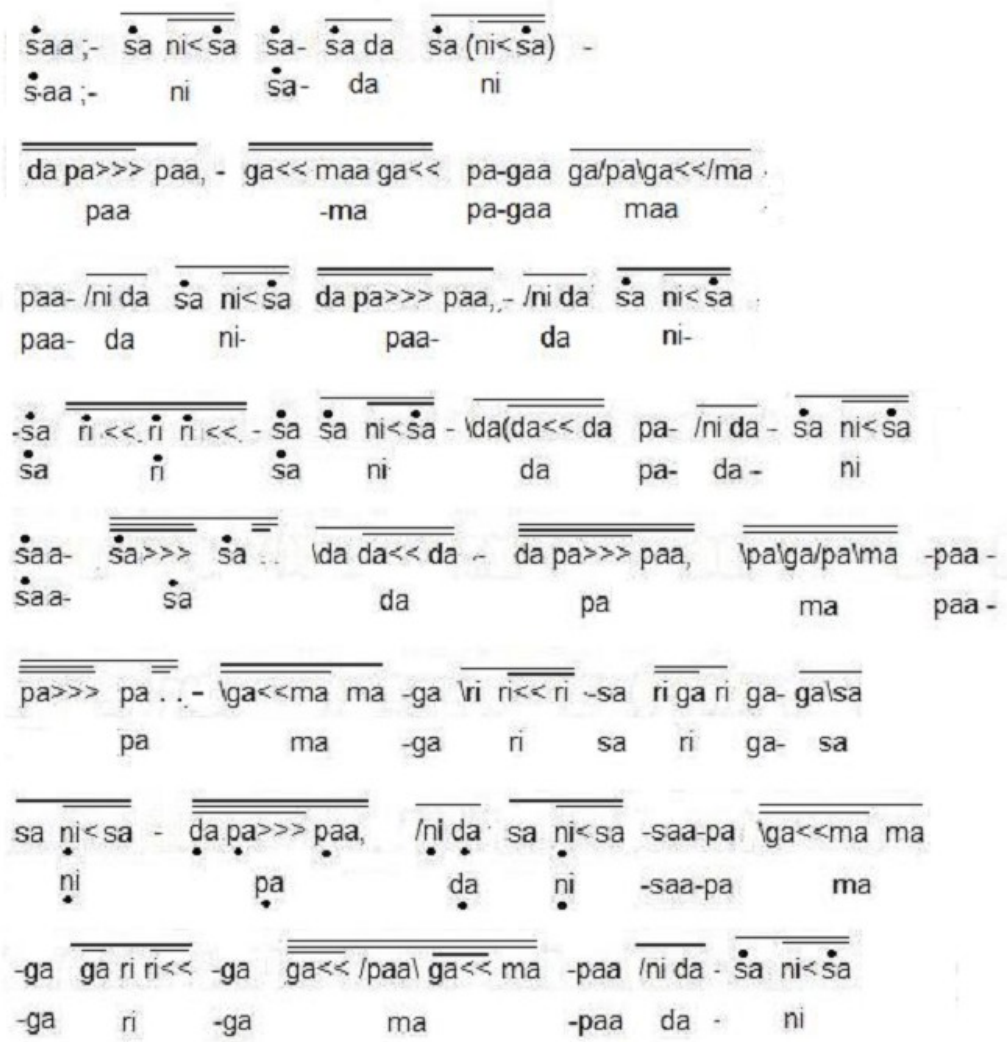
http://gamakam.tripod.com

It can be seen from the audio examples that continuity between notes and phrase indication is itself sufficient in fast phrases (ex. Kanthimathi in Kanada, second sangathi of the pallavi). With prolonged notes considerable modifications are required to get the true raga bhaavam.

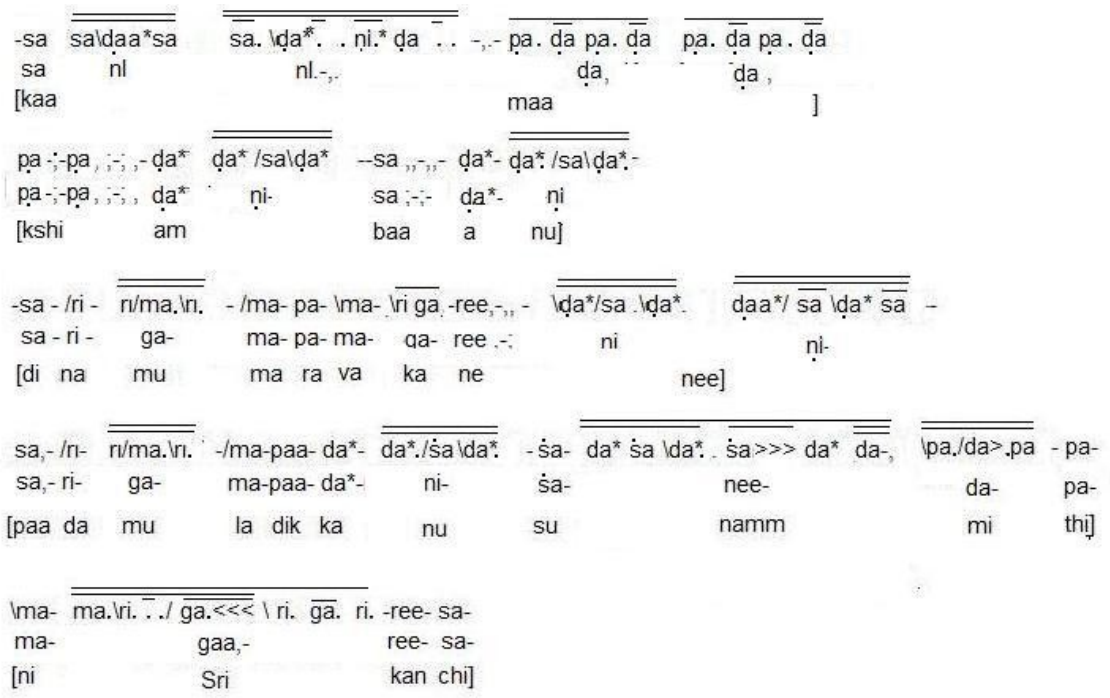
Extracts of bare notation and converted notation (both in Gaayaka format) are given in the same web page at the end.

9. Notation examples: In the website the notation is given in Gaayaka format (which uses upper and lower cases for the octaves and brackets for double and higher tempos). Examples of notation redone in the familiar format (except for the symbols "<" and ">" which change the pitch minutely and use of a dot as equivalent of the duration of half a note) are given below. Extensive use of higher tempos, even eight times normal, may be seen in the converted notation. This becomes necessary as the anuswarams are held for very brief durations.

a. Part of Varnam in Sankarabharanam (this was set at .36 seconds per whole note)



b. Part of swarajathi in Bhairavi (by Shyama Shastri) - set to .44 seconds per whole note (extensive gamakam in the note ni could be seen - oscillating from da to Sa)



References:

1. “Synthesizing Carnatic Music with a Computer“, M.Subramanian, Journal of Sangeet Natak Akademi, New Delhi, 133-134 (1999) pages 16-24

2. Website describing features of Gaayaka : http://carnatic2000.tripod.com/gaayaka.htm

3. “Carnatic Ragam Thodi: Pitch Analysis of Notes and Gamakams“, M.Subramanian, Sangeet Natak, VolXLI, No.1, 2007 - para 2.1

3a. “Carnatic Ragam Thodi: Pitch Analysis of Notes and Gamakams“, M.Subramanian, Sangeet Natak, VolXLI, No.1, 2007 - para 3.2

4. English version of Sangita Sampradaya Pradasrsini is available at http://www.ibiblio.org/guruguha/ssp.htm in 3 .pdf files. Gamakam symbols used in the work are explained at the beginning as a separate topic in each of the files.

5, Sangita Svararaga Sudha by Mallikarjuna Sharma, A. (2001) : Sai Sannidhi Sangita Publications, Hyderabad, A.P., India

6.Web site of Arun Kumar http://arunk.freepgs.com/gcreate/

7. Web site http://gamakam.tripod.com of the author has some audio examples of the computer converted notation

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