A UNIFIED SYSTEM FOR ANALYSIS AND REPRESENTATION OF INDIAN CLASSICAL MUSIC USING HUMDRUM SYNTAX

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ABSTRACT

Chordia proposed a new system for the analysis and representation of *bandiṣes* (bandishes) and *gaṭs* (gats) in Hindustani music using humdrum syntax (Frontiers of Research in Speech and Music Conference, 2007). In this paper, we extend the capabilities of this system to encode Carnatic music and propose a unified system for Indian classical music. It enables us to systematically encode Carnatic music compositions into a machine readable format. The **carnatic representation builds on the **bhat representation, with additional changes to incorporate the elements from Carnatic music such as *gamakas*, 16 *śṛti*, and a more complex *tāla* system. The linear text-based intermediate representation for data entry is also extended to encode additional metadata useful in Carnatic music. The representation system will be useful for symbolic music research, generation of synthetic melodies, and comparative analyses.

1. INTRODUCTION

Hindustani and Carnatic music traditions of India are predominantly oral traditions. Until 20th century, there was very little effort to develop and study written music notation. A systematized notation is useful for mass education, pedagogic comparative musicology studies, preservation of compositions, and unification of several styles. Major efforts during 20th century in this direction can be attributed to several scholars such as V. N. Bhatkhande (Bhātakhaṇḍe) [1] in Hindustani Music and subbarāma dīkṣitar (Subbarama Dikshitar) [2] in Carnatic Music. We now have a fairly consistent and uniform notation in both these music styles.

With recent interest and advances in Music Information Retrieval (MIR), there have been attempts to develop machine readable notation for use in MIR tasks. Humdrum toolkit [3] is one such effort developed by David Huron to systematically encode the long existing western music notation into a machine readable format. We can then develop large repositories of symbolic music and use them in several applications.

Development of such a symbolic machine readable notation for Hindustani music is a recent effort. Parag Chordia [4] developed a system for the analysis and representation of *bandiṣes* and *gaṭs* in Hindustani music using humdrum syntax. In this paper, we extend this system to Carnatic music and present an unified encoding scheme for both Hindustani and Carnatic music based on the **bhat syntax.

Indian music notation that is presently used varies across regions and is still evolving. Since Indian music traditions are predominantly oral, written notations are limited in use. They are to be interpreted by musicians and performers in a performance context and supplemented accordingly. At best, the notation can provide the most basic exposition of a song. Further, notation cannot be completely comprehensive and capture all the subtle elements of a performance, which mainly depends on the performer's virtuosity. However, even a limited notation can be useful for MIR research. The aim of this paper is to present a unified system for representing Hindustani and Carnatic music in a machine readable format. The primary intended use is by a computer and the notation is not necessarily intended to be familiar to musicians. The purpose of such a notation is for efficient encoding of compositions for use in MIR tasks. Though there can be a lossless mapping between a musician friendly and machine friendly notation, both these notations are inherently non-comprehensive and and inadequate to model all the subtleties of a music performance.

A machine readable format of symbolic music is useful in a variety of applications. Large symbolic music repositories can be built using this format. They serve the purpose of preserving compositions and pedagogy. From the viewpoint of MIR research, they are primarily useful for large scale statistical comparative studies. They can be used for generating synthetic melodies and storing automatically generated transcriptions. Other MIR applications where such a system of representation would be useful are melodic transcription, melody prediction and continuation through melodic sequence modeling.

Using a widely accepted music notation, we develop a machine readable notation. We first describe the existing system for Hindustani music. We then describe the chal-

Figure 1. The representation system

Carnatic		Western Scale	Hindustani		Humdrum: **kern,
Name	Notation	Degree (Note)	Notation	Name	**bhat, **carnatic
Ṣaḍja	S	C	S	Ṣaḍj	c
Śuddha Ṛṣabha	R1	Db	r	Kōmal Ṛṣab	d-
Catu:śr̥ti Ṛṣabha	R2	D	R	Shuddh Ṛṣab	d
Śuddha Gāndhāra	G1	D	R	-	d
Ṣaṭśr̥ti Ṛṣabha	R3	Eb	g	-	e-
Sadharana Gāndhāra	G2	Eb	g	Kōmal Gāndhār	e-
Antara Gāndhāra	G3	E	G	Shuddh Gāndhār	e
Śuddha Madhyama	M1	F	M	Shudh Madhyam	f
Prati Madhyama	M2	F#	m	Tīvr Madhyam	f#
Pañcama	P	G	P	Pañcam	g
Śuddha Dhaivata	D1	Ab	d	Kōmal Dhaivat	a-
Catu:śr̥ti Dhaivata	D2	A	D	Śuddha Dhaivat	a
Śuddha Niṣāda	N1	A	D	-	a
Ṣaṭśr̥ti Dhaivata	D3	Bb	n	-	b-
Kaishiki Niṣāda	N2	Bb	n	Kōmal Niṣād	b-
Kakali Niṣāda	N3	B	N	Śuddha Niṣād	b

Table 1. Equivalence of Indian svaras and western notes, with the corresponding representation in **kern, **bhat, and **carnatic representations (listed in the non-decreasing order of pitch)

lenges in extending the notation to Carnatic music. We propose a unified system of representation for Hindustani and Carnatic music. We also present some example encoded compositions and discuss the advantage and limitations of such a system.

2. EXISTING SYSTEM

The existing encoding scheme for bandiṣes and gaṭs is called **bhat encoding, and is based on the **kern representation in humdrum syntax. Since most of the music notations of bandiṣes and gaṭs are not available electronically, an intermediate ASCII based representation was also proposed. This intermediate representation is human readable and provides a mid-way between musician readable and machine readable notation. The composition would be manually encoded into this intermediate representation. It would then be parsed by an encoder and encoded into **bhat notation. The encoding process is shown in Figure 1. A complete description of the system and **bhat notation for Hindustani music can be studied in [4]. A detailed description of Humdrum syntax and **kern representation can be found in [7], [3]. An example composition encoded in **bhat is shown in Figure 2.

3. **CARNATIC ENCODING

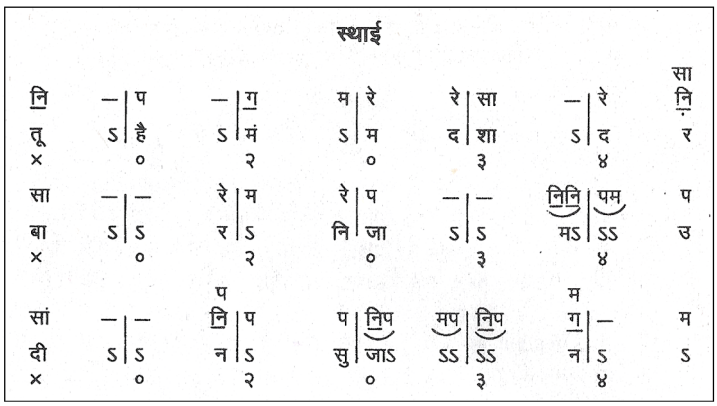
We describe a representation in humdrum syntax for Carnatic music **carnatic, extending the **bhat notation. There are several challenges in extending the **bhat notation to include Carnatic music. Primarily, we see that 16 *śr̥ti* system, encoding the *tāla*, and *gamakas* are the main challenges to be addressed. To supplement, an intermediate notation for manual data entry is also described. The intermediate notation is intended to be a direct extension of the well known musical notation but with an explicit representation of the *svaras*, tāla, gamakas, and other metadata. Hence, the **carnatic representation comprises of a method for manual/automatic data entry in the form of an intermediate representation, and a fully machine readable representation in humdrum syntax.

In our transcription experiments, we use the notation and compositions from Perfecting Carnatic Music vol. I and II by Chitravina N. Ravikiran (Citravīṇā N. Ravikiraṇ) [6]. This is a book primarily intended for beginner students of Carnatic music and provides clear and unambiguous notation. We use [6] to obtain the ASCII intermediate representation and then use our custom scripts to convert into humdrum syntax.

3.1 Svaras in Carnatic music

The Carnatic music scale is based on just-intonation, with 16 svaras (scale degrees). The svaras in Carnatic music are different from the twelve-note system of Western and Hindustani music, but an equivalence between the svaras of Carnatic music, svars of Hindustani music, and the notes of Western music is shown in Table 1, assuming the tonic to be at middle C. The table also shows the symbol for the svaras used in **kern, **bhat, and **carnatic notations. Even though the *svarasthānas* do not exactly correspond to the equivalent notes listed in the table, within the context of the present system, we adopt the notation from Humdrum syntax to be used with **carnatic. An accurate generation of synthetic melodies would need the exact svarasthānas, but since the present mapping does not lead any ambiguity or loss of information, we will continue to use the symbols borrowed from **bhat. We ignore the lyrics for the present, though the lyrics can be included on a separate spine in humdrum syntax.

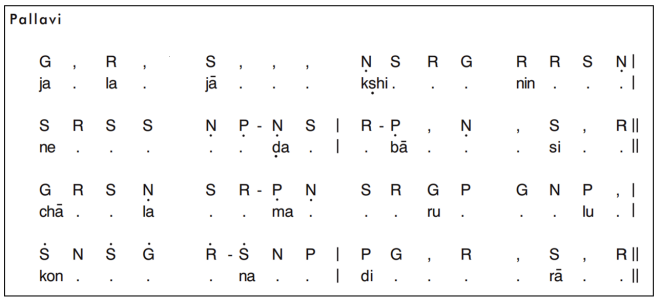
The intermediate representation explicitly encodes the dif-




```
id: jha2011
vol: 2
page: 11
sthayee: Tu hain mammadshah
raag: suha
taal: ektaal
tempo: madhyalaya
//n -/ P  -/ g  M/ R  R/ S  -/ R  >Sn,/
//S -/ -  R/ M  R/ P  -/ -  nn/ PM  P/
//S' -/ -  >Pn/ P  P/ nP  MP/ nP  >Mg/- M/
```

```
!!!id: jha2011
!!!vol: 2
!!!page: 11
!!!sthayee: Tu hain mammadshah
!!!raag: suha
!!!taal: ektaal
!!!tempo: madhyalaya
**kern
*MM240
*Isitar
*c:
!!data://n -/P -/g M/R R/S -/R >Sn,/
==1
2b-
=
2g
=
4e-
4f
=
4d
4d
=
2c
=
4d
cq
4B-
```

Figure 2. *Sthāyī* of the composition *tū hain maṁmadśā* in rāg *sūhā* and *ēktāl* encoded in **bhat notation. The music notation in [5] (vol. II, pp. 11) (Top Left), Intermediate representation (Bottom Left), and **bhat machine readable Humdrum syntax (showing only the first tāl cycle) (Right)




```
id: ravikiran2024p
vol: 2
page: 24
varnam: Jalajaakshi
raag: hamsadhwani
taal: adi
tempo: madhyalaya

// G3 - R2 - / S - - -/ N3, S R2 G3/ R2 R2 S N3,/
S R2 S S/ N3, P, N3, S/ R2 P, - N3,/ - S - R2/

// G3 R2 S N3,/ S R2 P, N3,/ S R2 G3 P/ G3 N3 P -/
S' N3' S' G3'/ R2' S' N3 P/ P G3 - R2/ - S - R2/
```

```
!!!id: ravikiran2024p
!!!vol: 2
!!!page: 24
!!!varnam: Jalajaakshi
!!!raag: hamsadhwani
!!!taal: adi
!!!tempo: madhyalaya
**kern
*MM
*I
*c:
!!data:// G - R - / S - - -/ N, S R G/...
==1
2e
2d
=
1c
=
4B
4c
4d
4e
=
```

Figure 3. The pallavi of *Jalajākṣa*, a *varṇaṁ* in rāga *Haṁsadhvani* and *Ādi tāla* encoded in **carnatic notation. The music notation in [6], vol. II, pp.24 (Top Left), Intermediate representation showing each cycle in two lines (Bottom Left), and **carnatic machine readable Humdrum syntax (showing only the first three beats) (Right)

ferent svaras in the composition. In most music notation, such as in [6], the notation provided initially includes the rāga and its structure explicitly mentioning the variant of R, G, M, D, N svaras occurring in the rāga. Since only one variant of each of the R, G, M, D, N occur in *arohana* and *avarohana* of the rāga, the composition then implicitly encodes the variant of the svara used, without actually labeling the variant. In other words, the variant of the svara used in the composition needs to be inferred from the rāga description provided before the composition. In the intermediate representation though, we provide a more explicit mapping of svaras, for the ease of conversion to humdrum syntax later. We explicitly encode the variant of the R, G, M, D, N svaras using the notation in Table 1 (column-2). The octave, rests and other encoding are similar to the **bhat intermediate representation. From this intermediate representation, the conversion to **carnatic representation uses the mapping as shown in the last column of Table 1. With the knowledge the rāga, the sequence of steps can be retraced back, which implies that the mapping is lossless.

3.2 Encoding Rhythm

The tāla metadata along with the beat indicators form a part of the rhythm encoding. In the intermediate representation, one *āvartanaṁ* is encoded in each line. Each line begins with a `//' to mark the beginning of the cycle and the beats of the tāla are separated by a `/'. The note durations are not explicitly encoded, but inferred from the number of notes in a beat. Each group of notes in the beat are separated by a space. The groups of notes occurring together without spaces are assumed to have the same duration. Further, all the groups of notes within beat are assumed to have the same duration. This way, a *tiśra naḍe* (triplet) can be indicated by three (or six, or twelve, depending on the tempo) single note/groups of notes within each beat. This makes the intermediate representation more intuitive. Though an explicit tempo (*kāla*) metadata is provided, the tempo can be inferred directly from the notation, e.g., a *dhṛta* tempo in *khaṇḍa* naḍe, Ādi tāla can be encoded using five groups of two notes per beat, with eight such beats. This notation can also encode the *eḍupu* (the phase of a composition) by starting the composition either before or after the start of the cycle (indicated by `//'). The rest of the cycle can be filled with `=' sign as in **bhat.

**carnatic notation uses the same encoding for durations as **bhat. Durations are encoded as the inverse of the fraction of the beat that the note takes, multiplied by a scaling factor (chosen as 4). The scaling factor is only for an equivalence to western music notation, and is of no other significance. In the case of a rest, the duration of the previous note is extended to the duration of the rest. Hence the tāla and naḍe information are implicitly encoded with the beat markers and the note durations.

3.3 Encoding Gamakas

Gamakas form the most important features in Carnatic music. Gamakas are more essential than ornamental in a Carnatic performance. Hence it is necessary to incorporate a suitable notation for gamakas in the present **carnatic representation. However, it is to be noted that the gamaka information is necessary only for a synthesis of a melody, but may not be completely necessary for other kinds of symbolic analyses on a computer. Further, certain rāgas have characteristic gamakas which can be obtained from the rāga metadata. In most of the cases, the music notation does not include gamaka information, but is learnt by the student directly from the teacher. This makes it difficult to include gamaka information in **carnatic notation.

**bhat provides a scheme for notating the *mīṇḍs* (glides), *kaṇ svars* (grace notes), and *khaṭkās* (turns). However, Carnatic music has many more gamakas which have been described. Inclusion of all the gamakas would need an exhaustive analysis and is a part of future work with more expert opinion. For the present, **carnatic includes the implicit gamakas indicated by the rāga's structure (*rāgalakṣaṇa*) and does not make an attempt to explicitly encode all the gamakas. This is a fair assumption given that the notation described here is for machine consumption, to be used for analysis, archival and to create large music repositories. However, to synthesize melodies, a gamaka synthesis block which uses the notation and adds the required gamaka would be necessary.

3.4 Metadata

**carnatic includes metadata which can be used in further analysis. The metadata is listed in no specific order at the beginning of the composition in intermediate representation and as comments in the humdrum **carnatic notation. Each composition has a unique ID to identify the composition. It also includes information about the location of the composition. The ID and the location metadata can be used to reach the exact composition. It includes the form (e.g. a *varṇaṁ*, a *kṛti*, *pallavi*, *caraṇaṁ*) and the name of the composition. The name begins with a capital letter and can be long, and might even include the lyrics in case of short compositions.The rāga, tāla, and the tempo are also indicated. Other metadata such as the composer, and other notes can also be indicated.

3.5 Example

An example composition encoded in **carnatic can be seen in Figure 2. *Jalajākṣa* is a varṇaṁ in the rāga *Haṁsadhvani*, *Ādi* tāla (8 beat cycle) and a composition by Manambuchavadi Venkata Subbaiyer. Haṁsadhvani has an ārōhaṇa-avarōhaṇa of S R2 G3 P N3 S' and S' N3 P G3 R2 S. We can see that the intermediate representation encoding the octave, variant of the R, G, N svaras, the beats of *caturaśra* naḍe, and the Ādi tala cycle of 8 beats (shown in two lines for better use of space here). The corresponding **carnatic shows the notes and their duration in each beat, in a **kern spine.

4. DISCUSSION

The **carnatic notation is an extension of **bhat notation to encode and represent Carnatic music. Both these notations use Humdrum syntax and hence can make use of

the analysis tools provided by the Humdrum toolkit [3]. This also provides a unified system for representation and analysis of symbolic music in the three traditions - Western, Hindustani, and Carnatic music. Though they share similar symbols and syntax for representation, the encoding provides the required flexibility to encode the unique attributes of each tradition. This allows for comparative symbolic music studies, and development of a common platform for MIR tasks which need symbolic music scores. There are many Western music datasets archived as **kern scores (`http://humdrum.ccarh.org/`). bandishDB [8] in **bhat notation is being built using V. N. Bhatkhande's Hindustāni sangīt-paddhati: kramik pustak mālikā [1] and abhinav gītāñjali by Ramashray Jha (Rāmāśray Jhā) [5]. A database using [6] is being built using the **carnatic notation for a preliminary symbolic music analysis for Carnatic music. However, music synthesis from these symbolic scores would require further culture specific approaches but can start from the described representation.

With certain modifications, **carnatic can be extended to encode rhythm. Chordia [9] proposed the **bol notation to represent tablā bōls. **bol can also be used to encode the *konnakkōl* syllables in Carnatic music. This can be useful for polyphonic transcription of Carnatic and Hindustani music.

5. CONCLUSIONS

In this paper, we extended the **bhat notation to Carnatic music developing the **carnatic notation which uses the humdrum syntax. This provides a unified symbolic notation and representation system for Indian classical music. The notation developed can efficiently represent the svaras and the tāla. The gamakas are of prime importance but the notation for gamakas in **carnatic is far from being comprehensive and complete. Further work in developing a better notation for gamakas is warranted. A sizeable database in **bhat and **carnatic needs to be developed for a thorough comparative analysis which would also lead to further improvements that might be required in the notation.

Acknowledgments

The authors would like to thank Prof. Hema Murthy and Ashwin Bellur at IIT Madras, India for their suggestions. The authors also would like to thank Dr. Ram Sriram and Vid. Bhavana Pradyumna in Atlanta, USA, Sagar Prabhudev in Hamilton, Canada, and Vid. Veena Srinivas in Goa, India for their valuable inputs in developing the notation presented in the paper. Special thanks to Vid. Chitravina N. Ravikiran (`http://www.ravikiranmusic.com`) for allowing his books to be used in transcription experiments.

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