Motivation

Melodic concepts like vadi, samvadi, nyas, graha svara:

> Lack of objective definition hinder the cause of music information retrieval

> Absence of quantitative evidence for qualitative terms like 'shine' or 'focus'

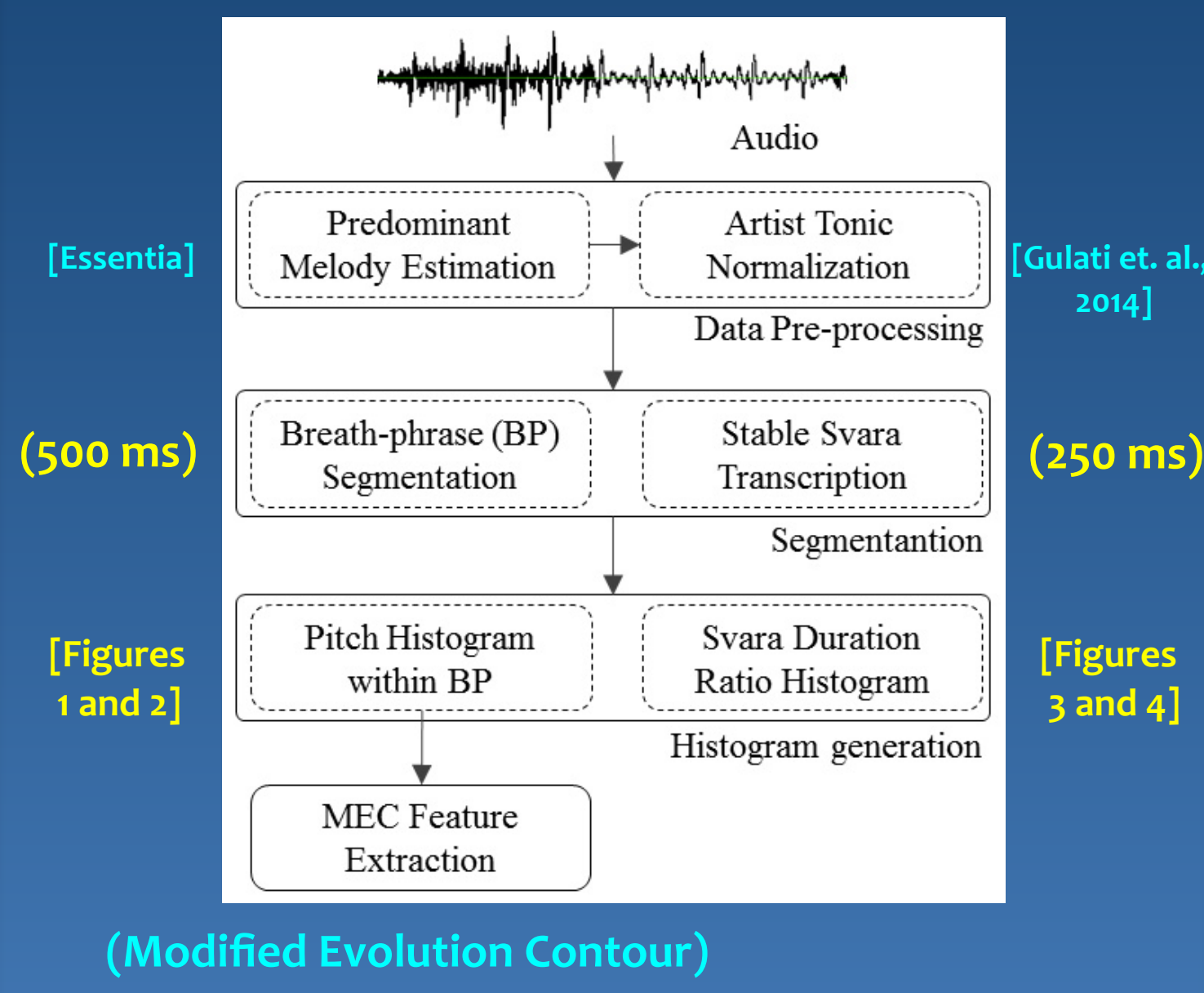> Manual analyses introduce subjective biases, and are not easily reproducible

Lack of studies at the time-scale of a full raga performance:

> Some attention has been paid to phrase-level modelling, which is not adequate to appreciate how a musician plans the evolution of the melody over the time-scale of the concert

> Pitch histogram model is useful for intonation analysis, but timing information is crucial for exploring melodic structures

How 'improvisatory' are the improvisations?

> What is the universal structure that underlies melodic improvisation, and is this raga-specific?

> How much of this is artist-dependent?

> Can the gharana (lineage) be inferred from a concert audio?

Case study concert:

> Artist: Ajoy Chakrbarty (male)

> Raga: Todi, Tala: Ektal, Laya: Vilambit (40 bpm)

> Svaras: S r g M P d N (7 svarasthanas)

> Duration: 335 sec (45 breath-phrases)

Data processing

[Essentia] Predominant Melody Estimation — Artist Tonic Normalization [Gulati et. al., 2014]
Data Pre-processing

(500 ms) Breath-phrase (BP) Segmentation — Stable Svara Transcription (250 ms)
Segmentation

[Figures 1 and 2] Pitch Histogram within BP — Svara Duration Ratio Histogram [Figures 3 and 4]
Histogram generation

MEC Feature Extraction

(Modified Evolution Contour)

Knowledge hypotheses

K1: Evolution of melody in time

Irrespective of the raga and concert-duration, artists take the same time to explore the melody and arrive at the highest svara

K2: Transitional characteristics of nyas svaras

Artists 'focus' on a nyas svara for consecutive breath-phrases to establish that svara before moving on to the next svara

K3: Relationship between functional roles of svaras and their duration in melody

Any svara in a breath-phrase cannot be stretched arbitrarily long, the nyas svara decides how much variance other svaras can exhibit

K4: Duration and position of svaras in melody

The performance starts from a lower svara (graha) and reaches the focal svara (vadi) in course of the gradual development of the melody

K5: Presence of possible pulsation in melody

There is an implicit pulsation present in the alap of Hindustani music, this carries forward to the tempo of the bandish
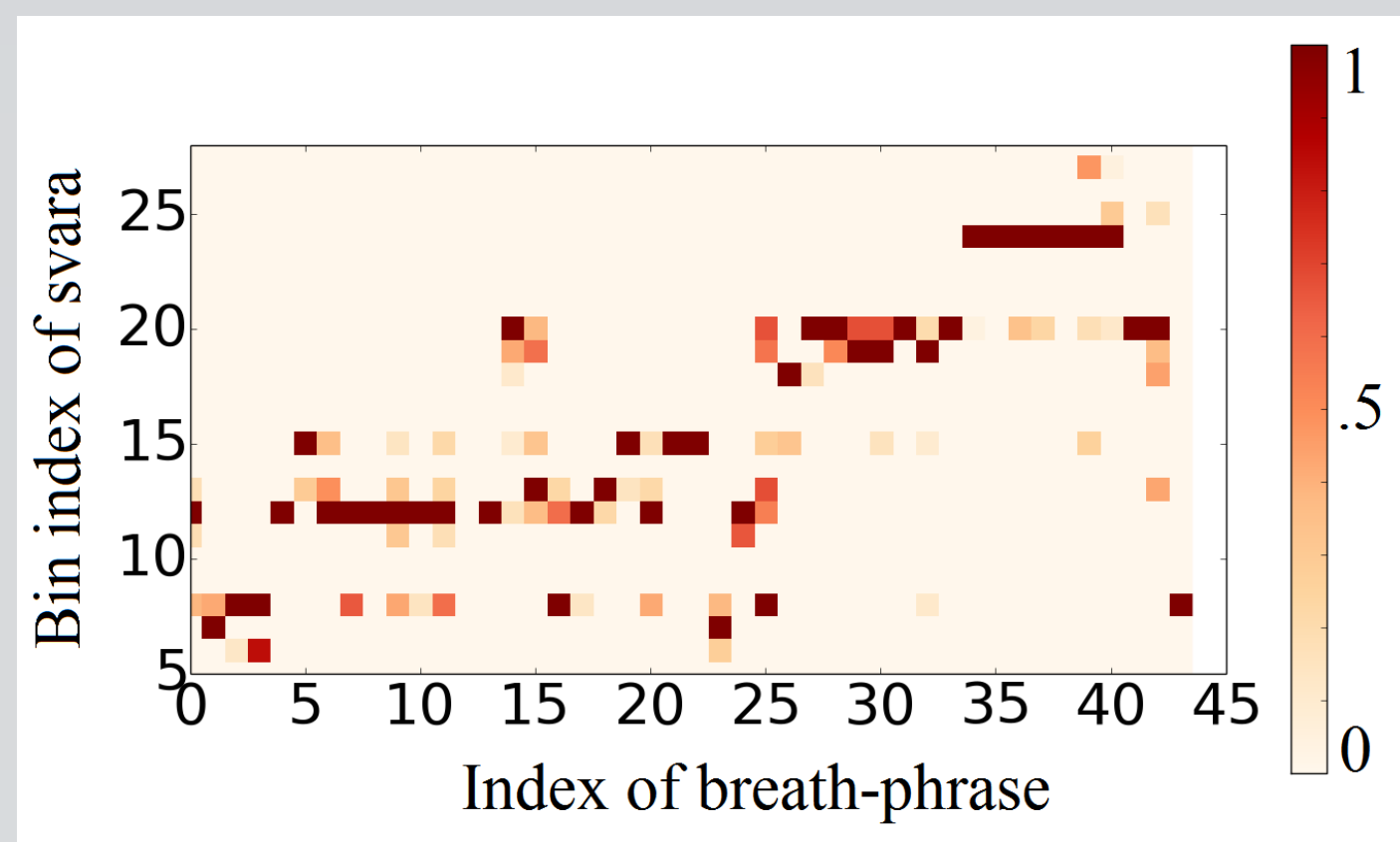
[van der Meer (1980), Widdess (2011), Bagchee (1998)]

K2

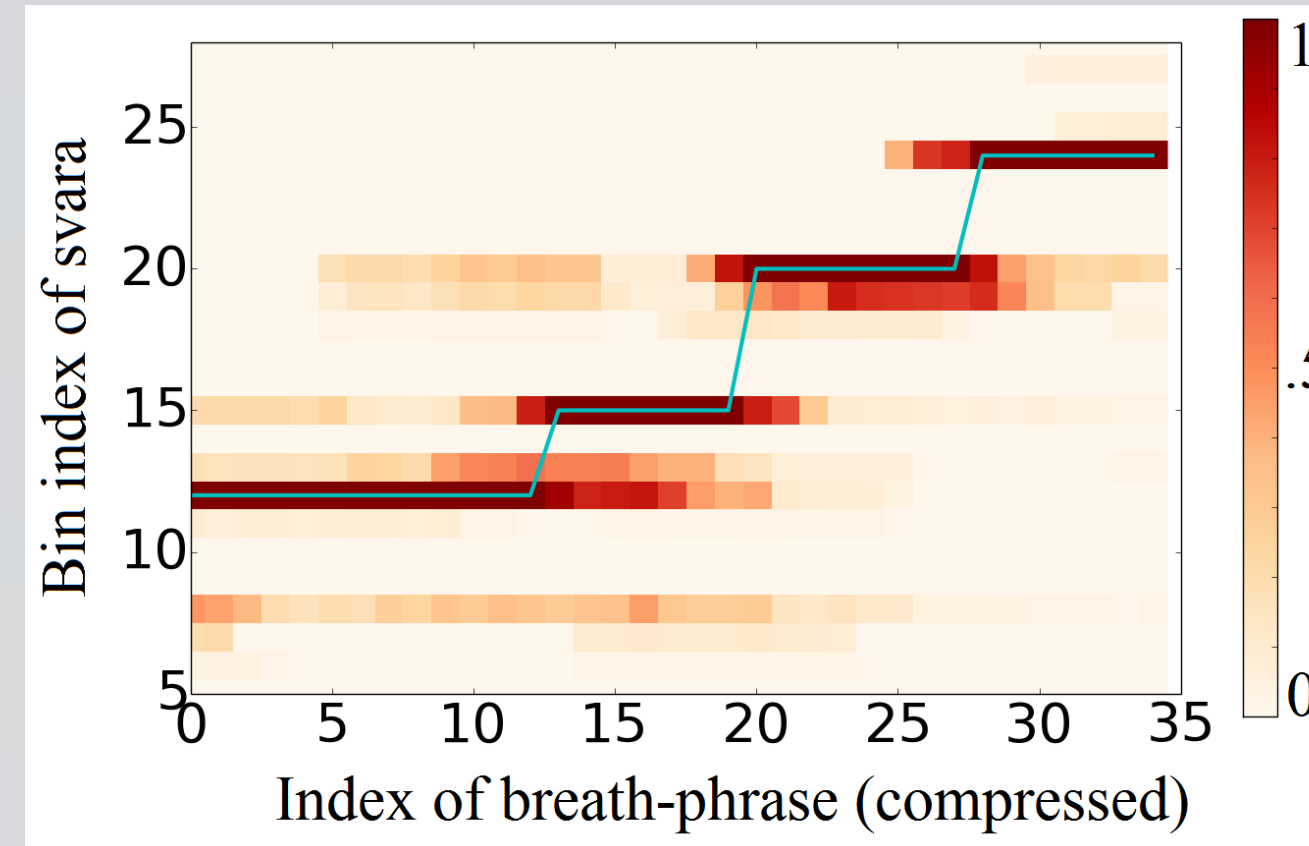Figure 1. Pitch histogram of svaras for each breath-phrase

K1

Figure 2. Smoothened (10 breath-phrases) pitch histogram superimposed with the evolution contour

K4

Figure 3. Bar graph of svara duration stacked in sorted manner for each breath-phrase. We observe that breath-phrases often comprise one long nyas svara and several other svaras of less duration
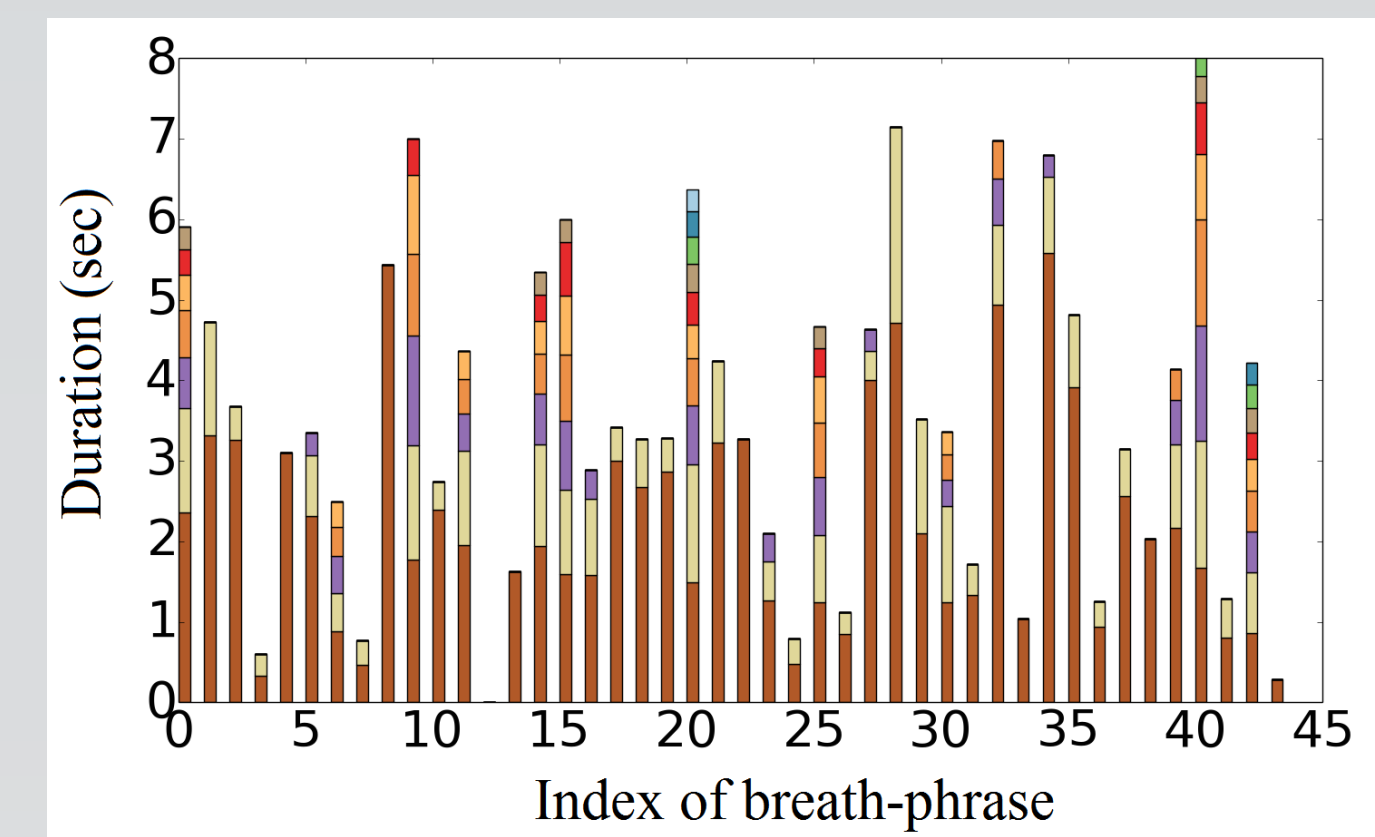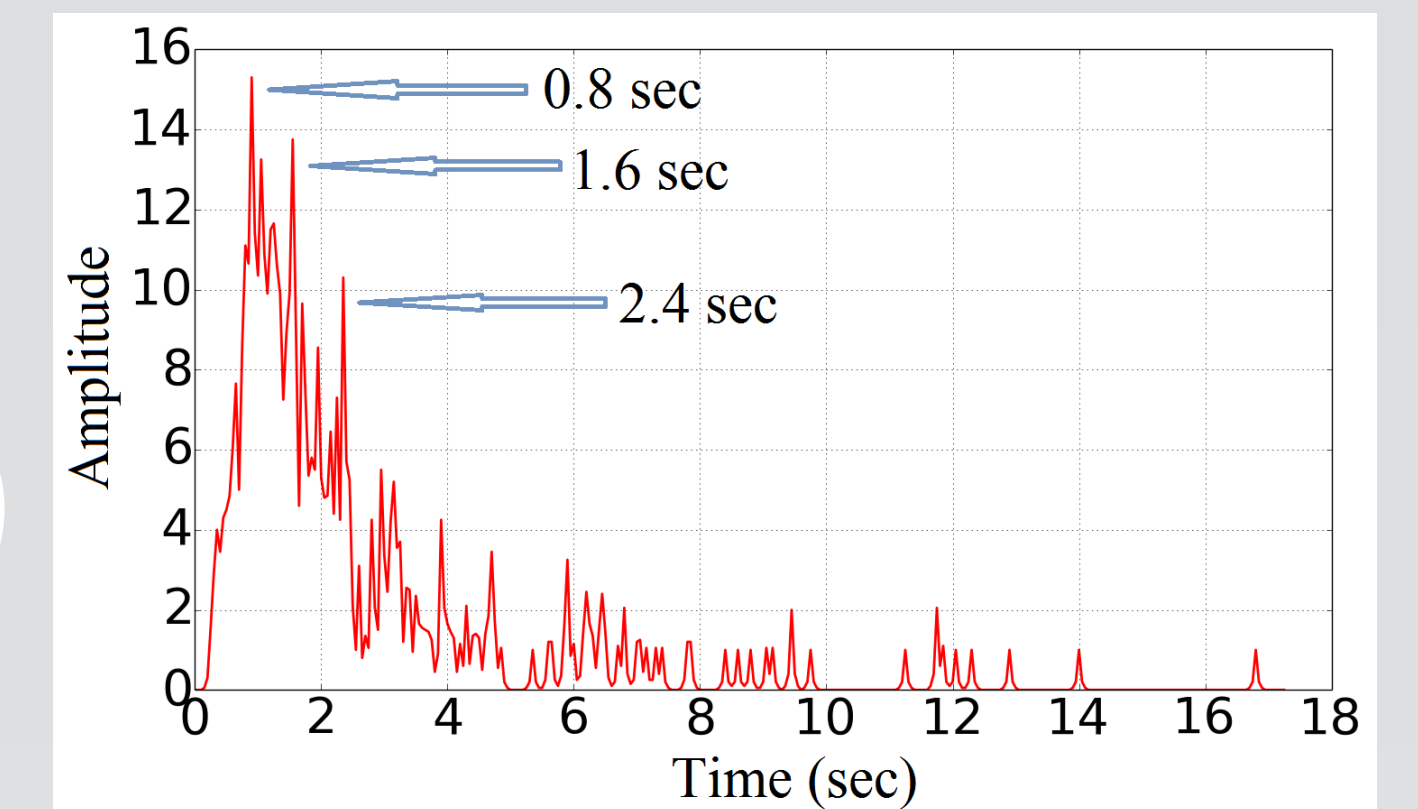

K5

Figure 4. Ratio of inter-onset-interval of salient svaras across breath-phrases. We see a tatum pulse (peak) at 0.8 seconds and its harmonics

0.8 sec
1.6 sec
2.4 sec

Data-driven exploration of melodic structures in Hindustani music

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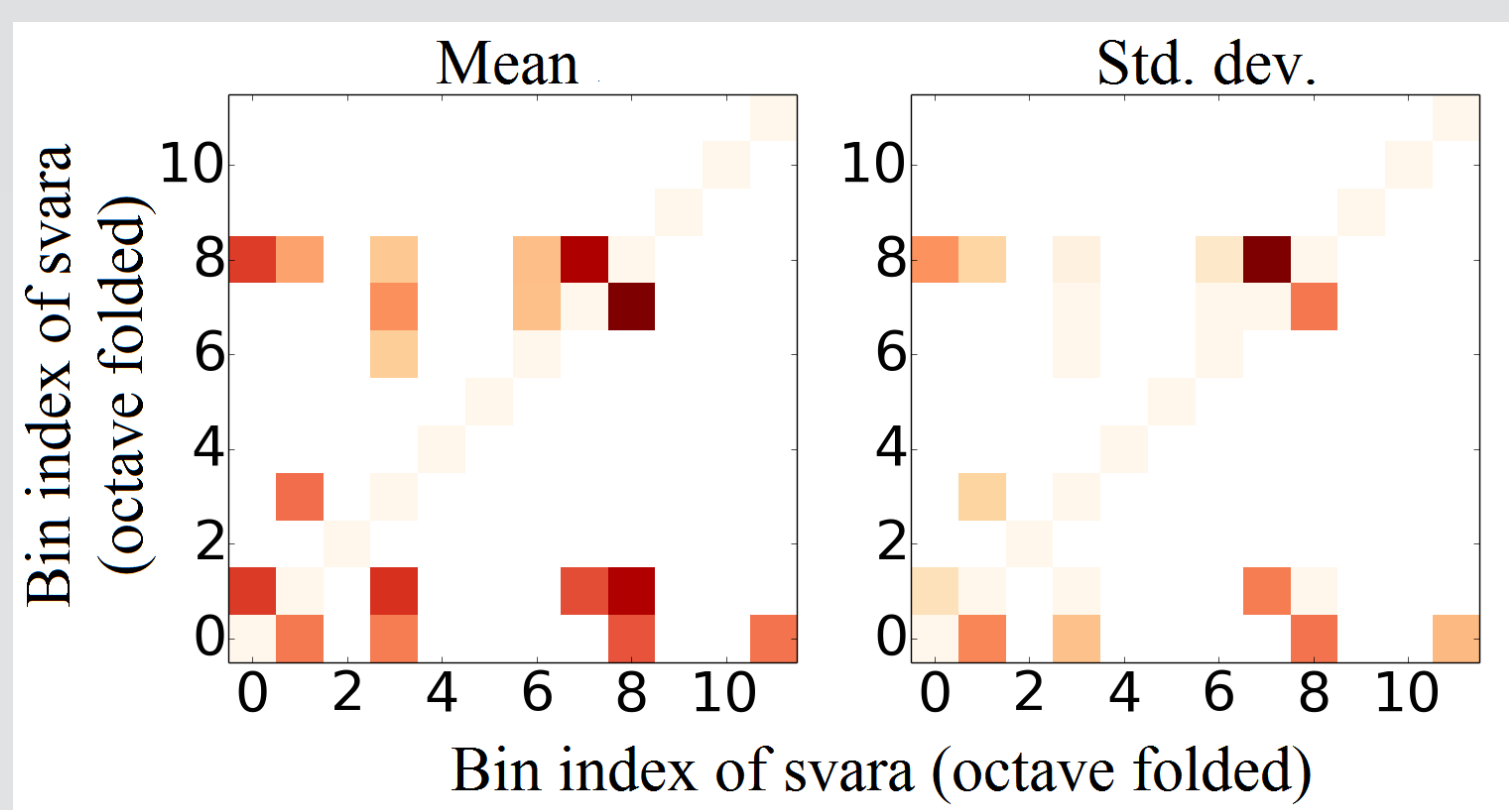
K2

Mean   Std. dev.

Figure 7. Mean (left) and standard deviation (right) of all svaras (octave folded) for each svara along x-axis being the salient svara in a breath-phrase

Svaras refer to transcribed steady note segments [Ganguli et. al., 2015]

Music collection & Annotation

> 75 concerts from 10 widely used ragas

> 40 eminent artists (male and female), 67 unique compositions

> Diverse in terms of number of svaras, their svarasthanas and layas of bandish

> A trained Hindustani musician annotated the end of alap and vistar section

> The corpus amounts to 20 hours of data

Modified evolution contours (MEC) for 37 concerts in our music collection

K3

Duration of breath-phrase
Number of notes in breath-phrase
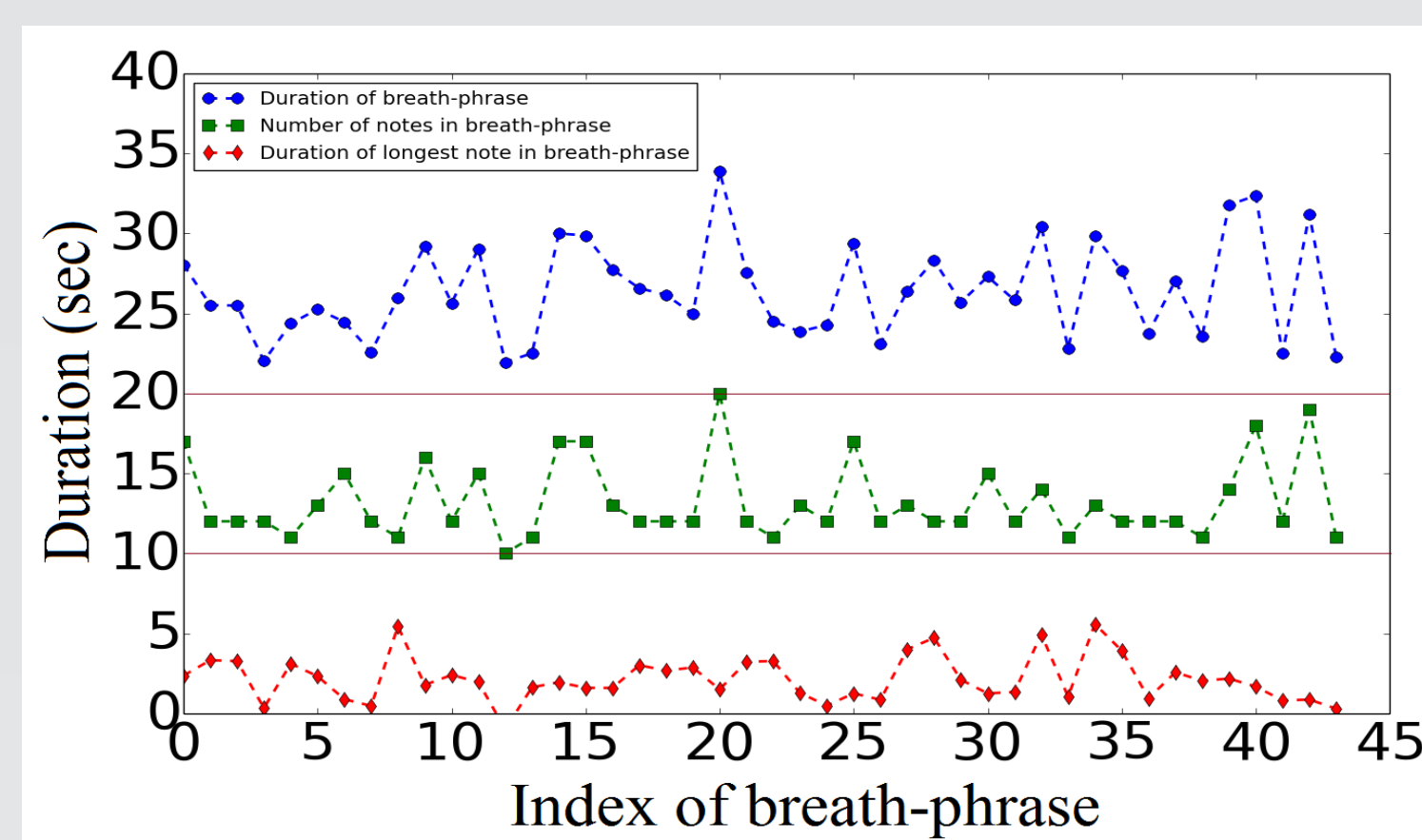Duration of longest note in breath-phrase

Figure 6. Heuristic features extracted from breath-phrases to observe correlation of svaras and their durations. The green (unit-less) and blue contours are with an offset of 10 and 20 sec for better visualization
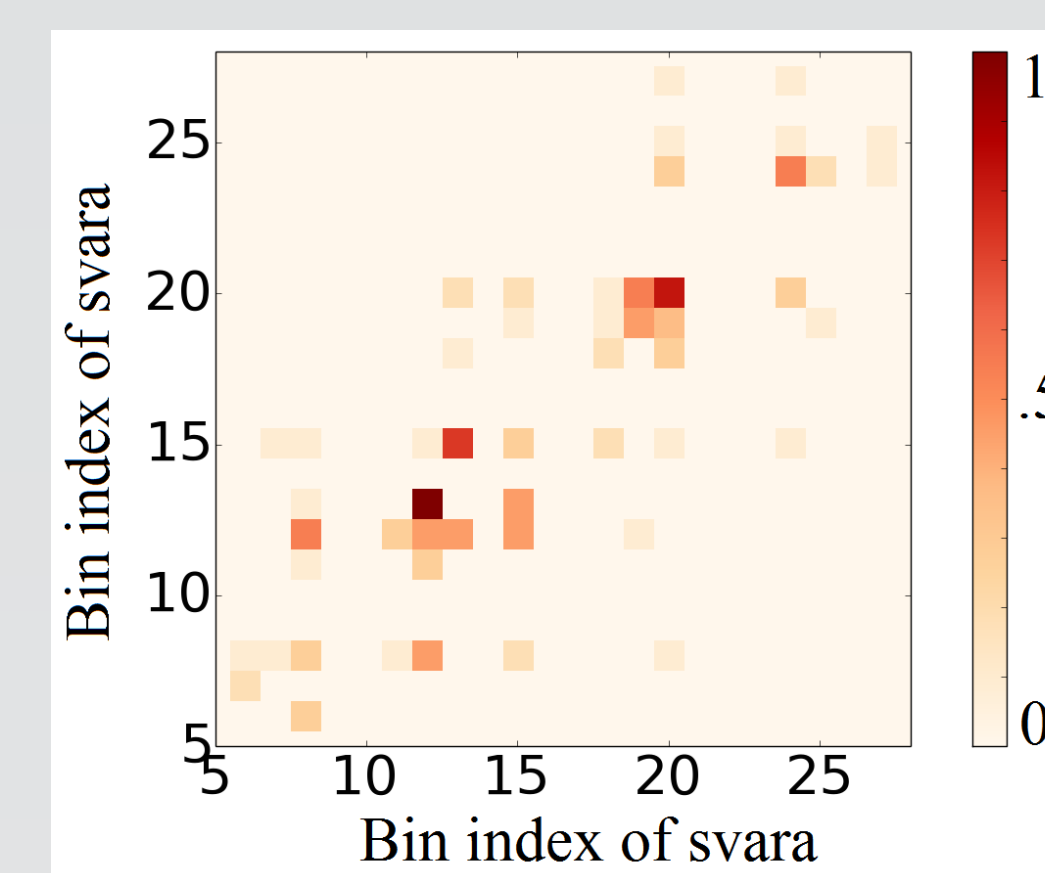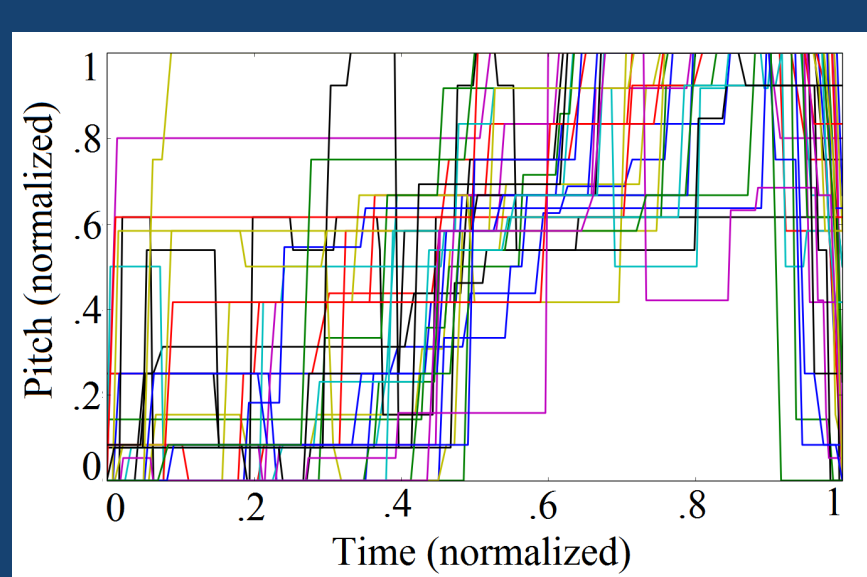
K2

Figure 5. Svara-transition matrix of salient svaras of each breath-phrase. Intensity of each bin is proportional to the number of transitions taken from the svara of bin index on x-axis to the svara of bin index on y-axis

MEC Feature Extraction

> A collection of heuristic features (slope-based, duration-based, jump-based, and level-based)

> Slp: slope between the MEC value of initial frame and the first frame where MEC=1

> Cen: centroid (salience of the bins as the weights is regarded) of each svara

> Pro: proportion of duration spent on each svara

> Feature selection in Weka reveals:

> Slp is a raga-independent feature

> Cen is a raga-dependent feature

> Pro for vadi/samvadi svaras is always higher

K2

Slp   Stq
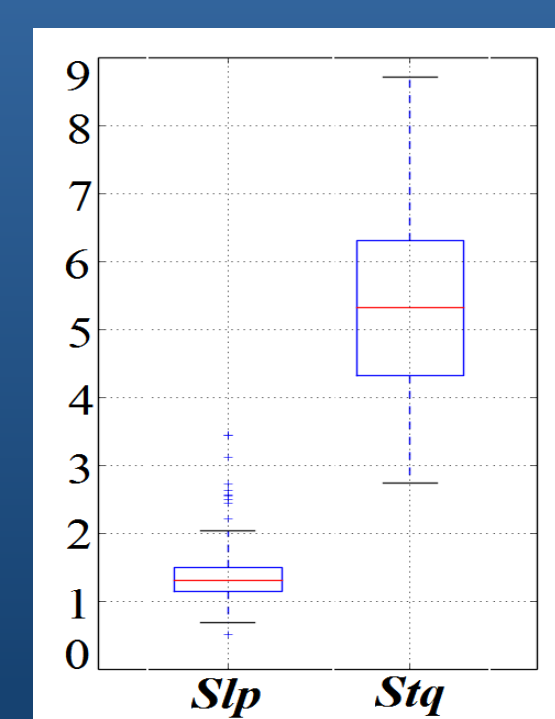
Stq is a feature obtained from svara-transition matrix, showing proportion of self-transitions

Summary

> We outline the motivation and relevance of computational approaches for quantitatively studying the underlying musical concepts

> Musically relevant acoustic features, computed using existing MIR tools and techniques, are intuitive and easy-to-interpret by musicians/musicologists

> We discover implicit relationships between svaras and duration in the temporal evolution of a raga performance which is useful in the music pedagogy

> Statistical analyses on a larger representative corpus shows that the validated hypotheses are generalizable

Future work

> Use these findings for characterizing artist- and gharana-specific melodic aspects in Hindustani music

> Incorporate timbre and volume dynamics with melodic features to study use of alankars in alap performances

> Corroborate the findings to propose a system that could provide qualitative (musically valid) feedback to music learners and aid compositional tools

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