

# Carnatic Music: A Signal Processing Perspective

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- ▶ Structure of a Carnatic Music Concert: A listener's perspective
- ▶ Gamakaas in Carnatic Music
- ▶ Characteristics of Gamakaas in Carnatic Music – a pitch based perspective
- ▶ Processing of Carnatic music using motifs
  - ▶ Source Separation: vocal and accompanying instruments – T-F motifs
  - ▶ Motifs of Gamakaas
  - ▶ Motifs of Raagas in terms of pitch and energy
- ▶ Scope for further work

# Structure of a Carnatic Music Concert: A listener's perspective I

- ▶ A concert is made up a sequence of pieces.
- ▶ The pieces correspond to different forms.
- ▶ Each form has a specific characteristic.
- ▶ Melodies are seldom repeated (except in thematic concerts)
- ▶ Elaboration of one or more pieces in a concert.
  - ▶ **Kriti:**
    - ▶ an alap, a composition (pallavi, anupallavi, charanam), neraval, swaraprasthara, solo accompaniment
  - ▶ **Raagam Taanam Pallavi (RTP):**
    - ▶ RTP: an alap, a taanam, a composition (pallavi only)
    - ▶ Pallavi is rendered at different speeds.
    - ▶ Swaraprasthara may include multiple melodies.
    - ▶ Rhythmic cycles chosen – complex (e.g. Adi taalam, (kanda nadai))
  - ▶ **Every concert has an aesthetic format which is like a story.**

# Gamakaas in Carnatic Music

- ▶ Written forms of a Raaga
  - ▶ ArOhana – sequence of notes in ascending order (generally starts from the tonic  $Sa$ ).
  - ▶ AvarOhana – sequence of notes in descending order (generally starts from the tonic  $\dot{S}a$ ).
- ▶ Vocal/Instrumental form of a Raaga
  - ▶ Replete with Gamakaas
  - ▶ Although specific placeholders – notes can meander quite significantly about the placeholder.
  - ▶ The “note uttered” and “note sung” need not have a one-to-one correspondence
  - ▶ Carnatic Music is primarily made for the vocal tradition.

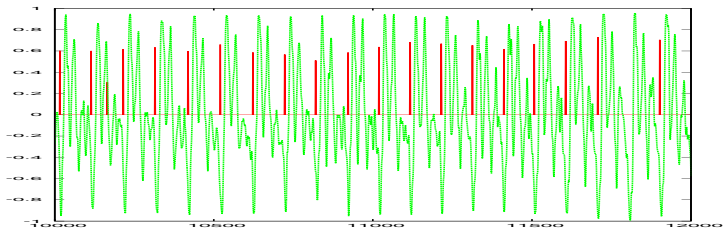
# Classification of Gamakaas (SSP – Subbarama Dikshitar, Dasavidha Gamakaa –as told to us by the experts)

- ▶ A finite number of meandering patterns are observed:
  - ▶ kampitam, jaaru, vali, spuritham, ...
- ▶ The Gamakaas are stitched together/one gamakaa is overlaid on the other
- ▶ Other than gamakaas, “brikhas” are also used..
- ▶ Standard set of melodic phrases are observed in every piece.

# How good are Signal Processing algorithms at extracting Gamakaas?

- ▶ Analysis by Synthesis
- ▶ Extraction of pitch contour (Significant instants)
- ▶ Estimation of vocal tract parameters using LPC.
- ▶ Synthesis using LPC and pitch contour.

# KVN Example I



The original KVN alaapana:



The synthesised KVN alaapana:



## Comments:

- ▶ Clearly the gamakaas are captured quite well.
- ▶ Experimented with a number of pitch extraction algorithms.
- ▶ Almost all pitch extraction algorithms seem to capture the gamakaas quite well.
- ▶ Goal: Extraction of features from the pitch contours:
  - ▶ Model various tasks – segmentation, phrase ID, voice ID, archival
  - ▶ Develop **machine learning algorithms** for various tasks?


# Characteristic Pitch and Spectrogram for some of the Gamakaas


Some example Gamakaas created by Vignesh Ishwar – tOdi

Kampitham: 

Jaaru: 

Odukkal: 

Nokku: 

Orikkai: 

# Gamakaas in a given alaap

Vignesh tOdi Alaap:



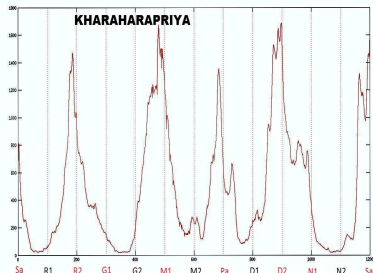
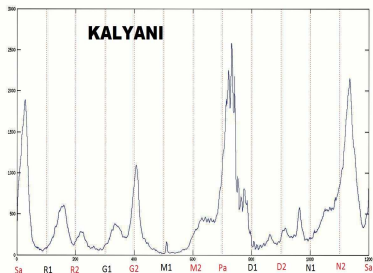
KVN bhairavi Alaap:



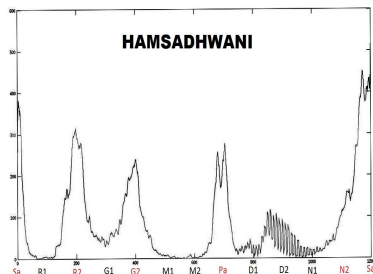
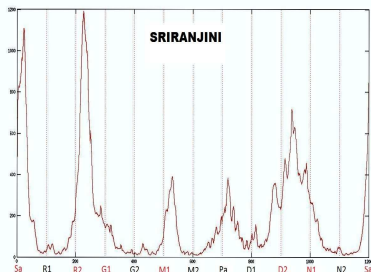
# Summary of pitch analysis on complete alaaps

- ▶ The musician does not seem to always stick to the grammar of the gamakaa.
- ▶ Some definite phrases do exist
  - ▶ Most keen listeners identify raagas without difficulty.
- ▶ A set of T-F motifs?
  - ▶ T-F masks of significant activity – needs exploration.
- ▶ Mapping from raaga to the language as defined by musicians required?
- ▶ Derive motifs for raagas using “machine learning?”

# Histograms of notes for different Raagas - a la “tunings paper: UPF” I



# Histograms of notes for different Raagas - a la “tunings paper: UPF” II



# Summary of Histogram Analyses: Observations

- ▶ Raagas with seemingly identical notes do not have similar ornamentation.
- ▶ Gamakaa associated with a note – perhaps depends on the proximity of the next/previous note?
- ▶ Variation of a note about the mean is quite different for different raagas?
- ▶ Histograms as a tool to visualise?



K V Naryanswamy - Sankarabaranam:

# T-F representations for source separation – some examples I

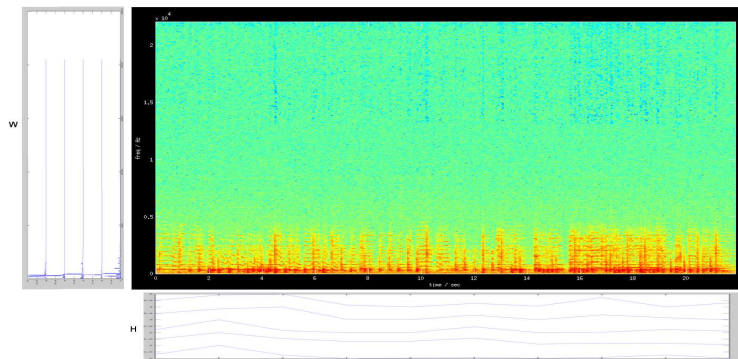
Non-negative Matrix Factorisation (NMF)

$$V = WH$$

where the factors  $W$  and  $H$  are non-negative:

- ▶ All elements must be greater than or equal to zero
- ▶ (Short-Time-Fourier-Transform) magnitude spectrum are chosen as  $V$ .
- ▶ The original phase of the STFT is used to resynthesis the signals.

# T-F representations for source separation – some examples II

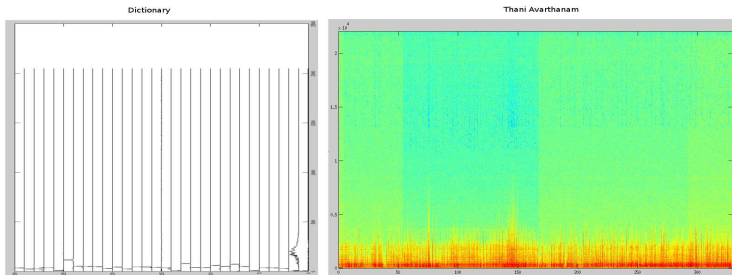



- ▶  $W$  are a set of T-F basis functions that serve as building blocks.
- ▶  $H$  activate the basis functions.

# T-F representations for source separation – some examples(contd)

Some ideas:

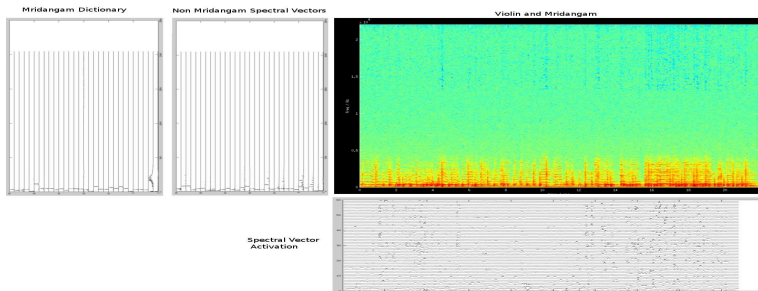
- ▶ Determine basis functions for each source, when the source is playing/ singing alone.
- ▶ Basis functions serve as a dictionary.
- ▶ Dictionary used to separate/detect sound.
- ▶ Example - Mridangam dictionary using *tani Avartanam*.



Mridangam alone 

# T-F representations for source separation – some examples(contd)

Source separation to extract mridangam and violin



Violin and Mridangam 

Mridangam 

Violin 

# Scope for further work

- ▶ Separation of sources to analyze them in isolation
- ▶ Automatic segmentation of pieces (inter and intra)
- ▶ Suppression of percussion to improve pitch extraction
- ▶ T-F representation to detect/distinguish gamakaas and phrases in music.