Carnatic Music: A Signal Processing Perspecive

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Outline

- Strucure 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 alaap, a composition (pallavi, anupallavi, charanam), neraval, swaraprasthara, solo accompaniment
  - Raagam Taanam Pallavi (RTP):
    - RTP: an alaap, 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 signficantly 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.

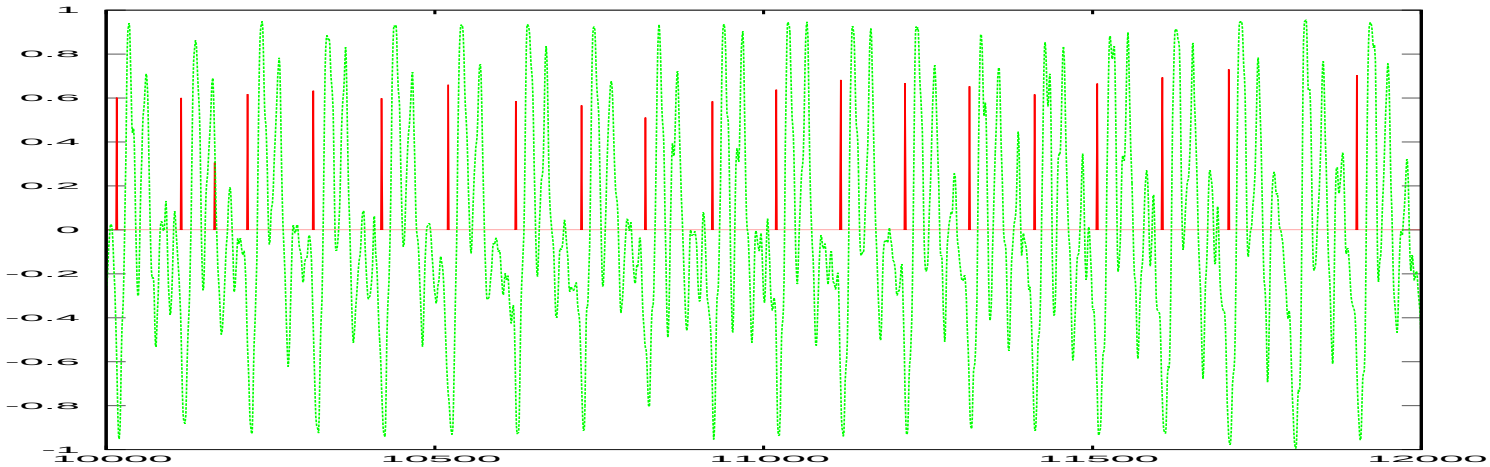
Classification of Gamakaas (SSP – Subbarama Dikshitar, Dasavidha Gamakaa –as told to us by the experts)

- A finite number of meandering patterns are observed:
  - kampitam, jaaru, vali, spuritham, ...
- The Gamakaas are stitched together/one gamakaa is overlayed 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:

KVN Example II

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

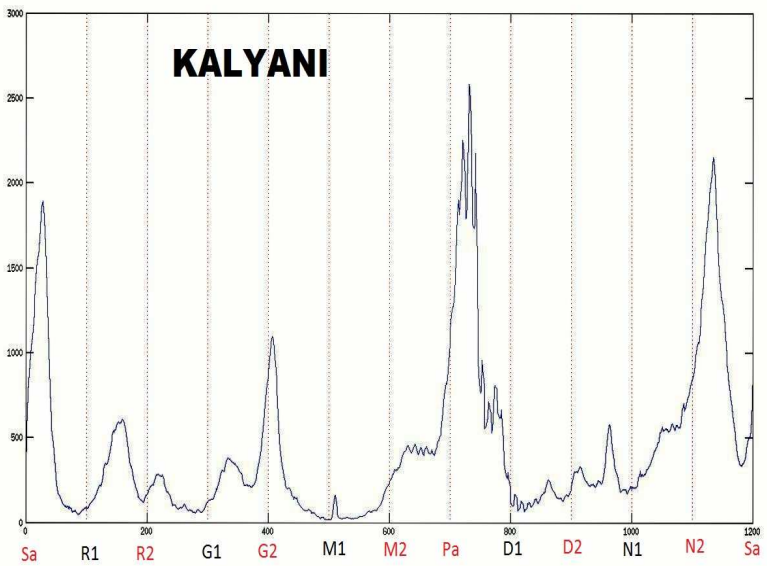
Vignesh tOdi Alaap:

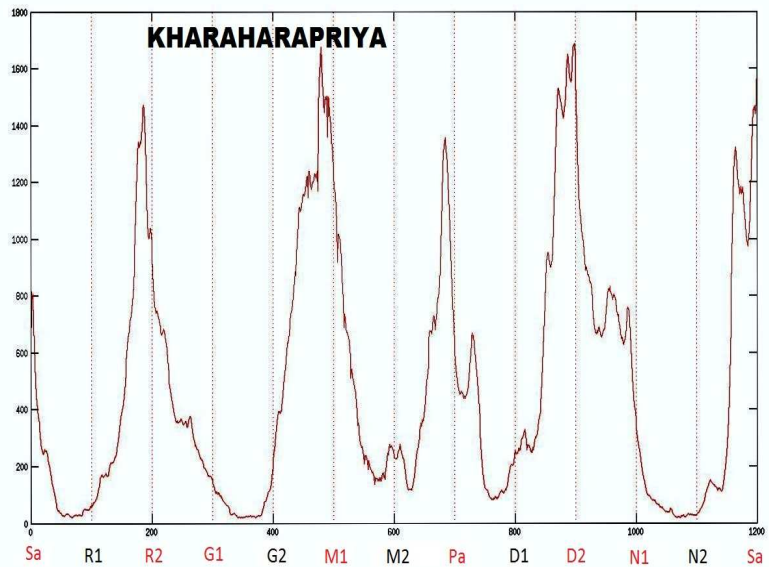
KVN bhairavi Alaap:

Summary of pitch analysis on complete alaaps

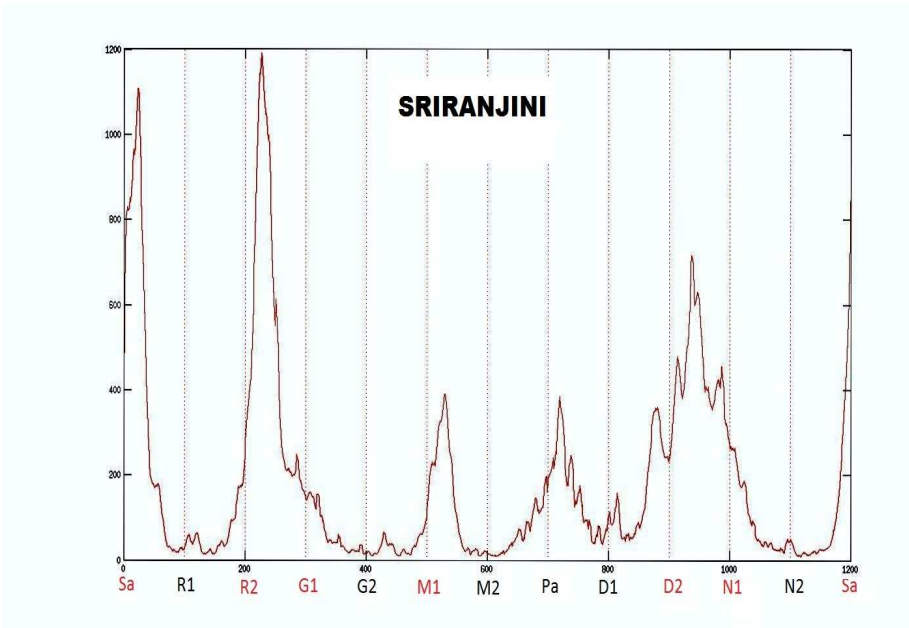
- The musician does not seem to always stick to the grammar of the gamakaa.
- Some definite phrases do exist
  - Most keen listeners identify raagas without difficulty.
- A set of T-F motifs?
  - T-F masks of significant activity – needs exploration.
- Mapping from raaga to the language as defined by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

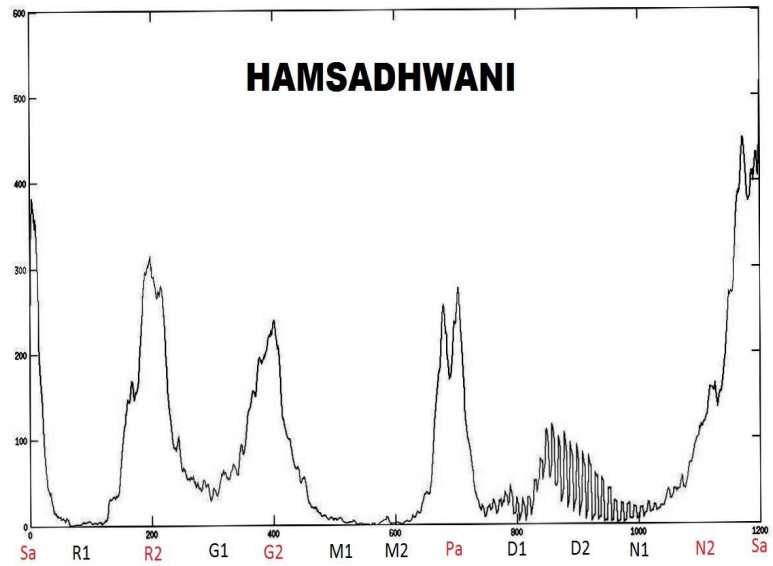
Histograms of notes for different Raagas - a la “tunings paper: UPF” I





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

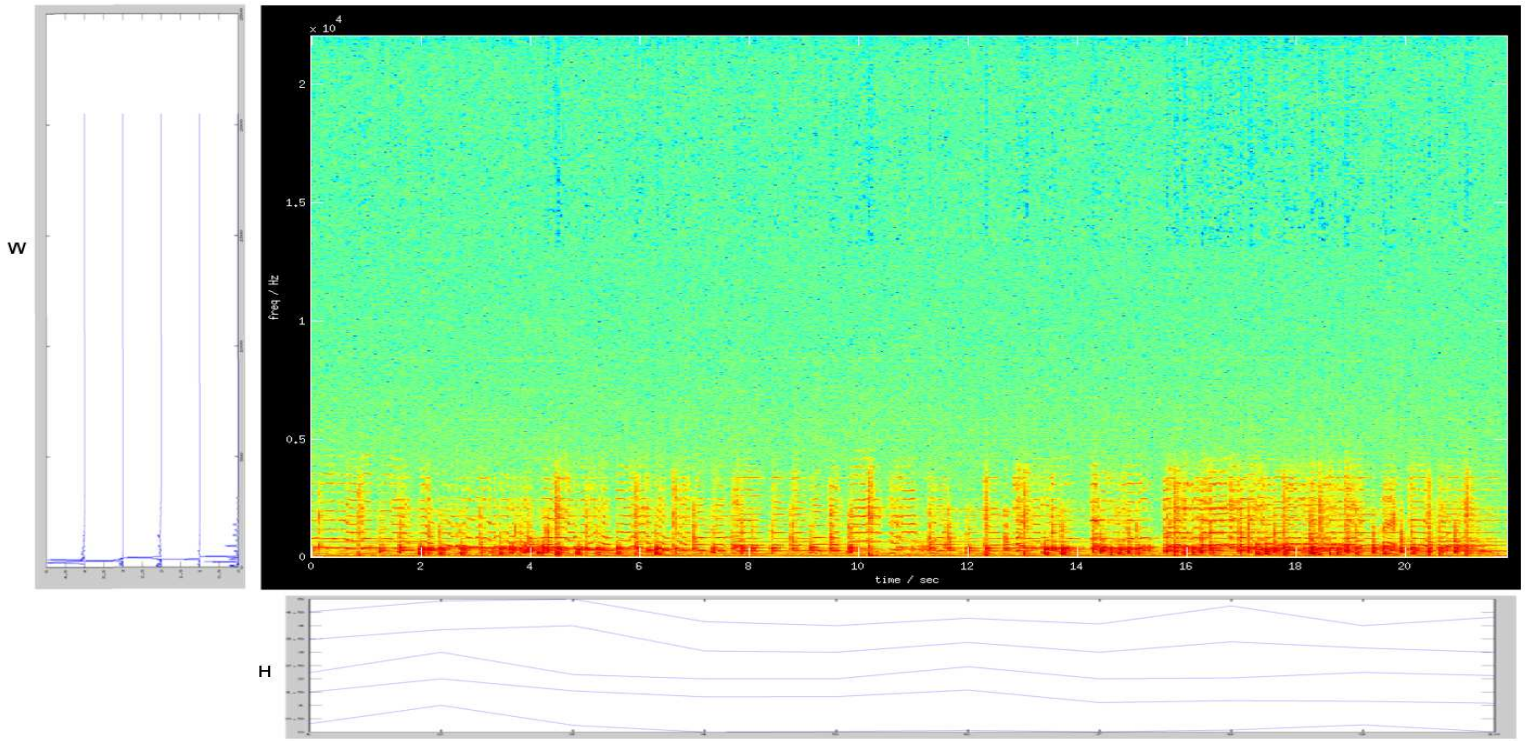
Non-negative Matrix Factorisation (NMF)

$$V = WH$$

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

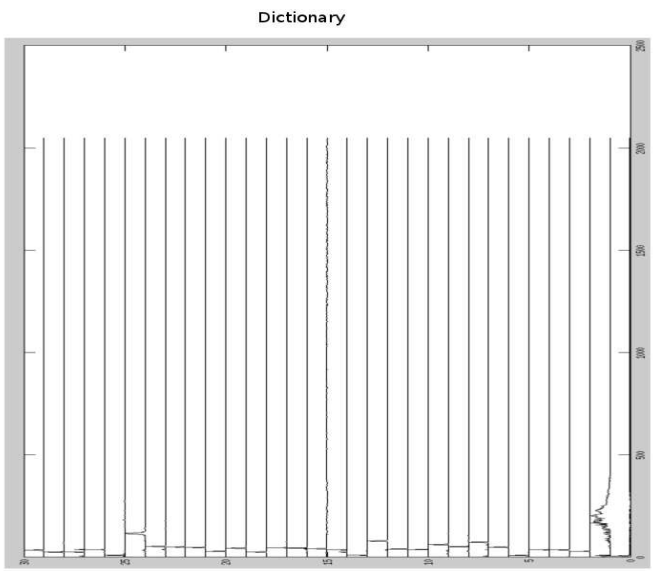


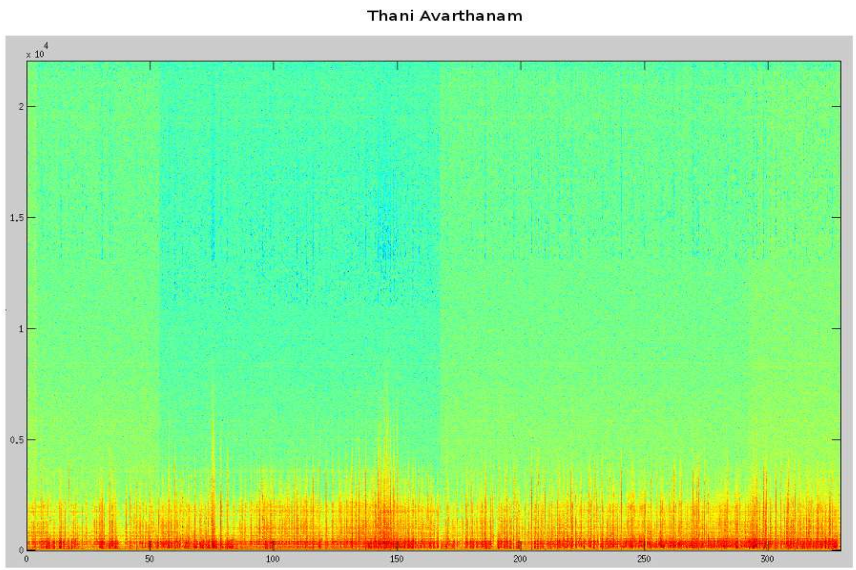
- W are a set of T-F basis functions that serve as building blocks.
- H activate the basis functions.

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*.

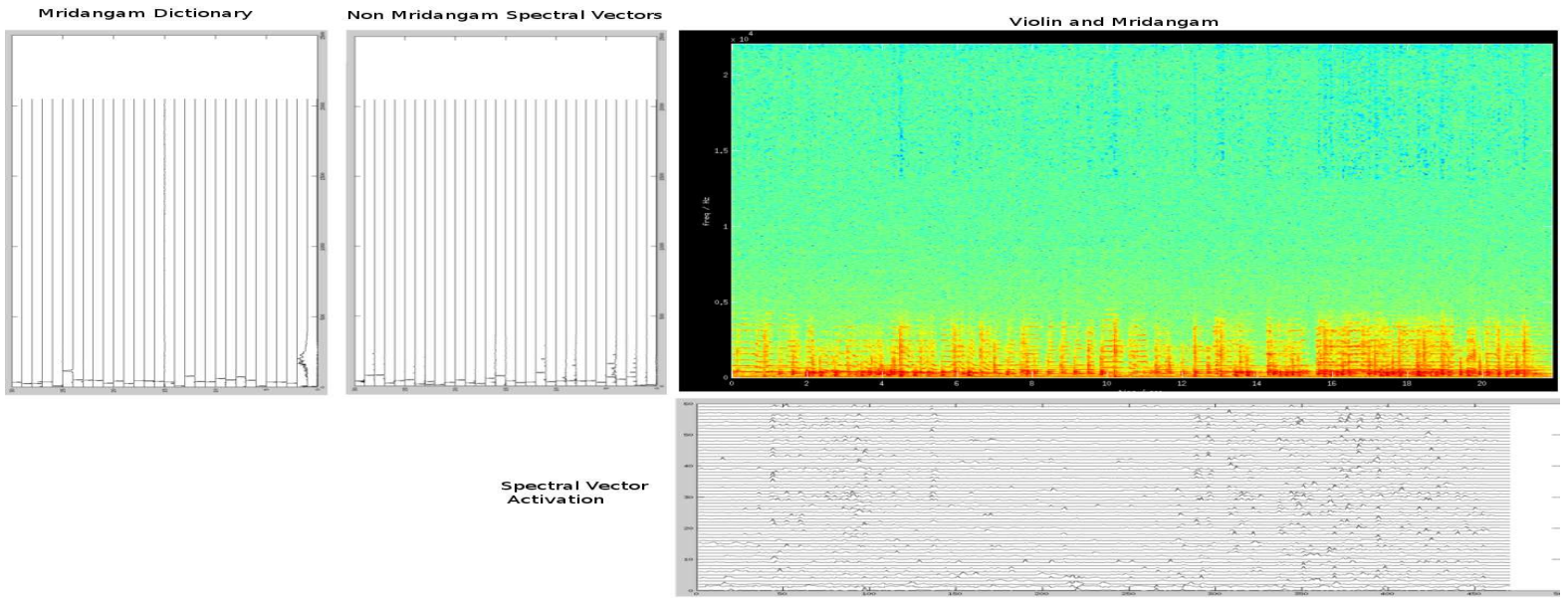




Mridangam alone

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)
- Supression of percussion to improve pitch extraction
- T-F representation to detect/distinguish gamakaas and phrases in music.