Computational Analysis of Intonation in Indian Art Music

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2nd CompMusic Workshop, Bahçeşehir Üniversitesi, Beşiktaş, Istanbul, Turkey

Topics

- What is intonation?
- Context and purpose
- Histogram parametrization
- Work in progress
  - Swara-based histograms
  - Pattern analysis
- Discussion & conclusions

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What is Intonation?

- Pitches used by a performer in a given performance.
- Our context: Pitch variations within a swara.
  - Eg: Ga_2 in Darbar and Nayaki 
- Relevant references
  - **Intonation**: Levy (1982), Belle et al (2009), Swathi et al (2009)
  - **Tuning**: Krishnaswamy (2003), J. Serrà et al (2011)

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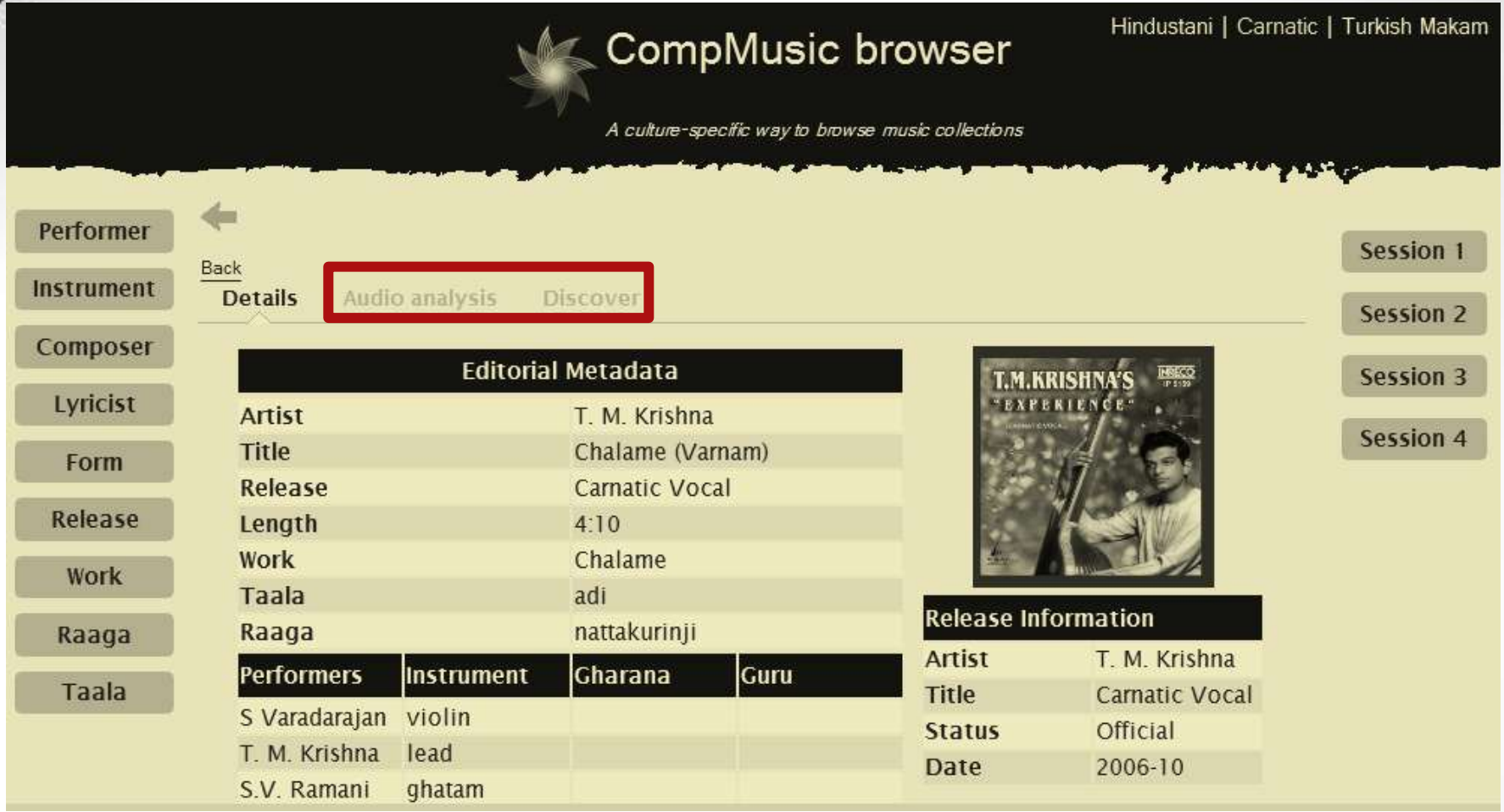

- Melodic analysis
  - **Intonation profile,** motives, structure and low-level features.
- Rhythmic analysis
- Metadata
- Web-data

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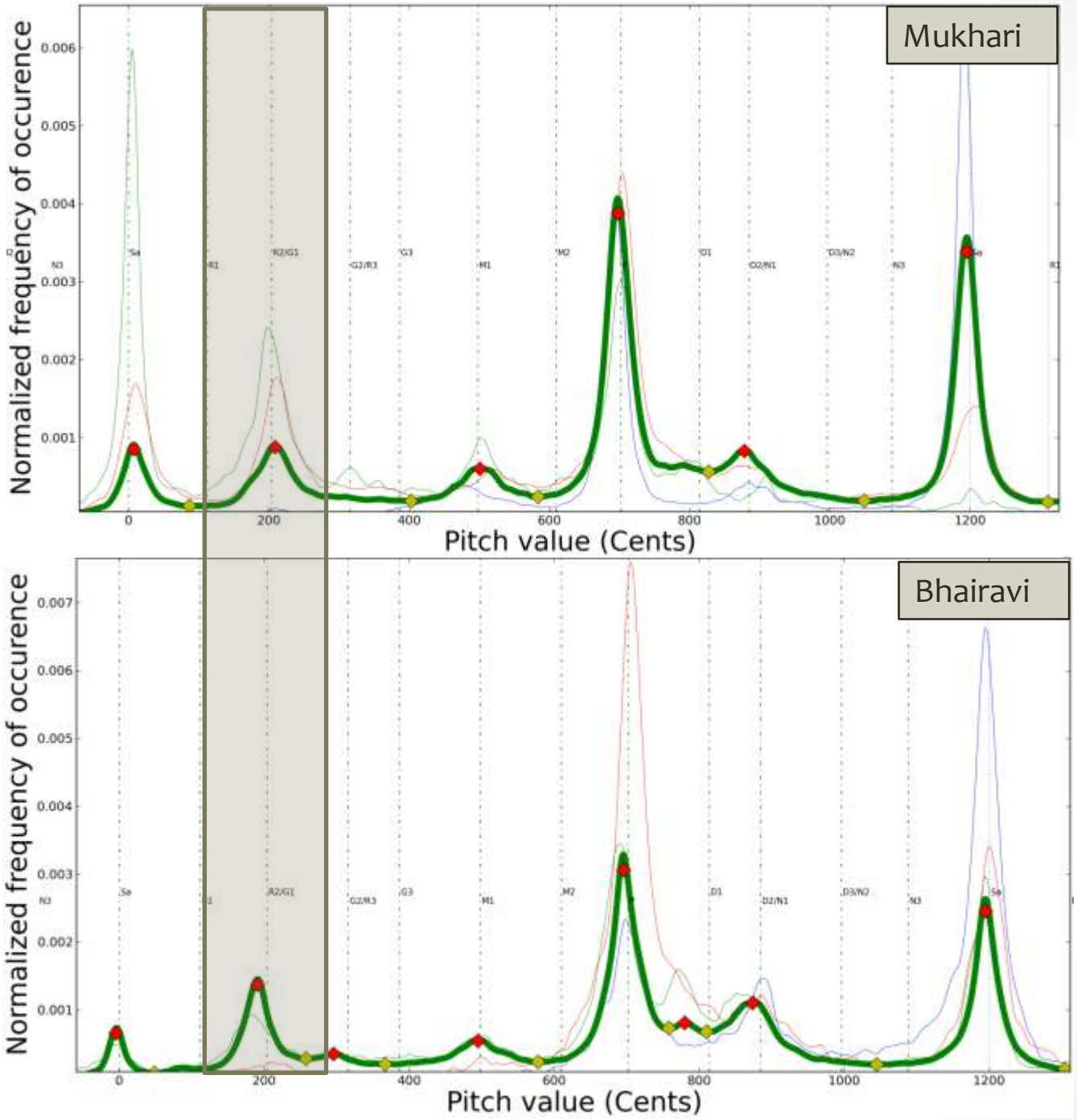
Histogram analysis – Goal!



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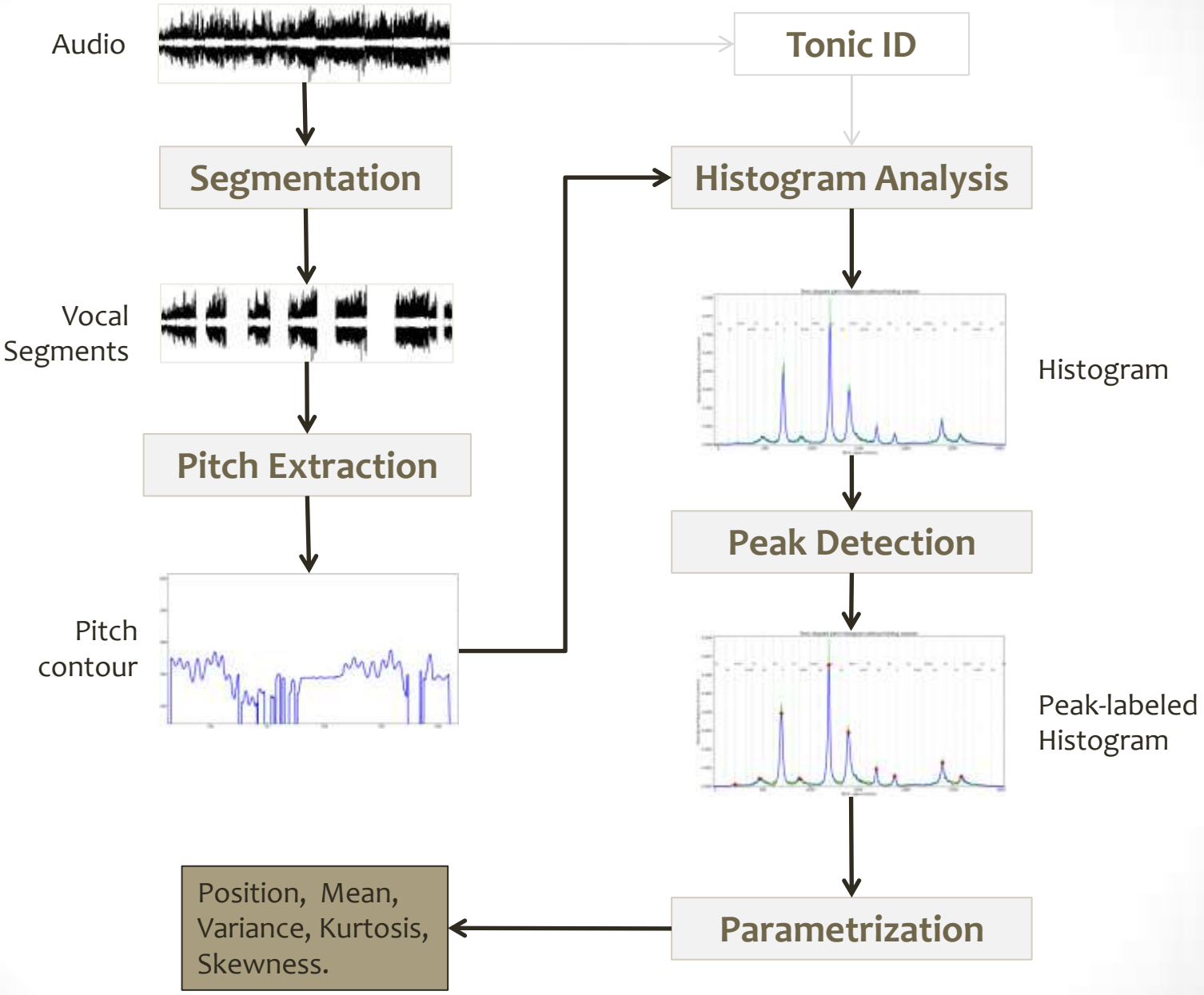
Overview of Method



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Segmentation

- Why just vocal segments?
- Segment classes
  - Vocal (solo/mix)
  - Violin (solo/mix with percussion)
  - Percussion (solo)
- Support vector machine model
  - Trained on 300 minutes audio data
  - Features: MFCCs, pitch confidence, spectral flatness, flux, rms, rolloff, strongpeak, zcr and tristimulus
- Accuracy: 96% (10-fold cross-validation test)

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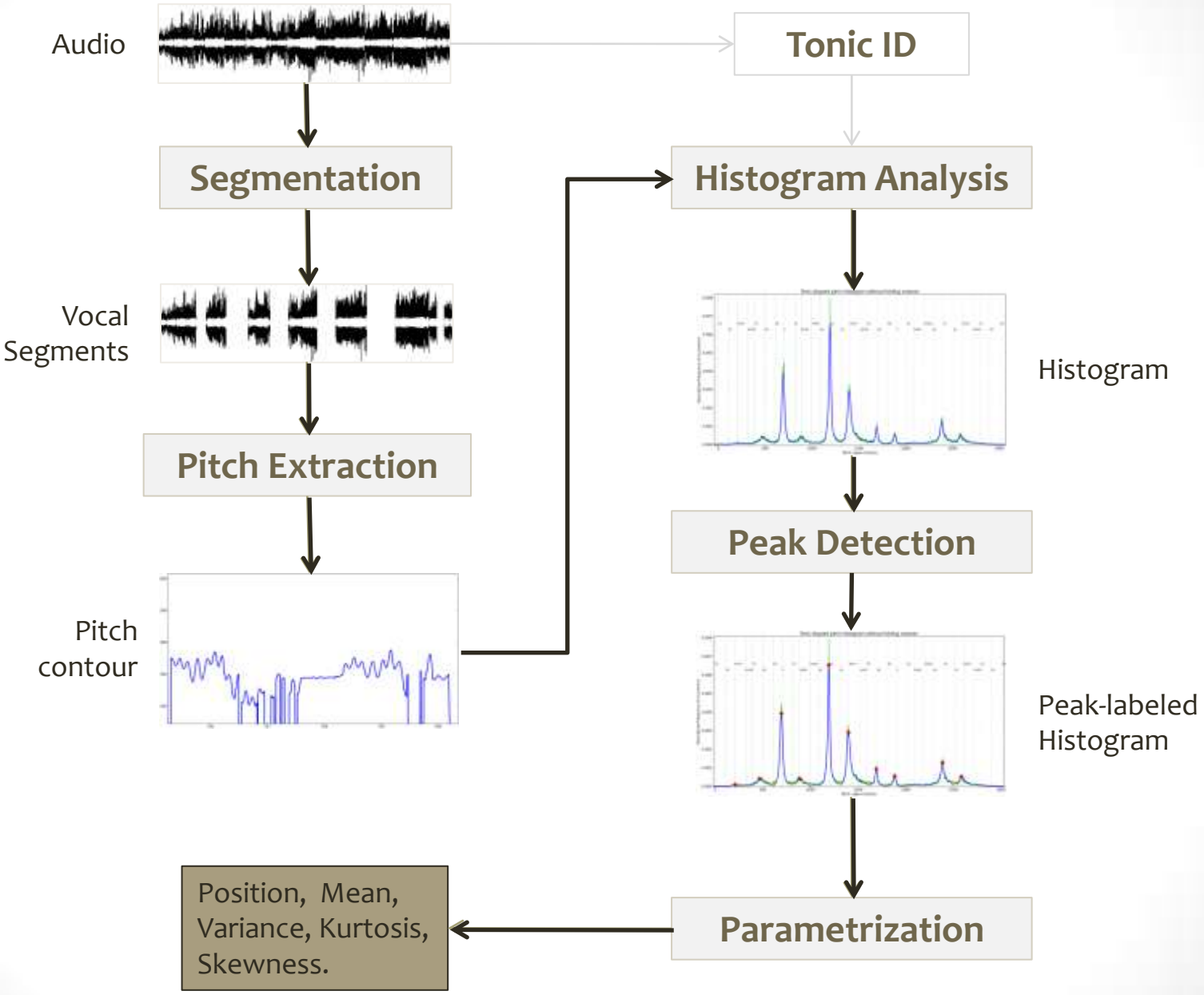
Audio
Tonic ID
Segmentation
Histogram Analysis
Vocal Segments
Histogram
Pitch Extraction
Peak Detection
Pitch contour
Peak-labeled Histogram
Position, Mean, Variance, Kurtosis, Skewness.
Parametrization

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Pitch Extraction

- Violin interference
  - Filling in the gaps
  - Mimicking with time-lag.
- Multi-pitch analysis
  - Predominant melody extraction
- Combination with YIN
  - Why?

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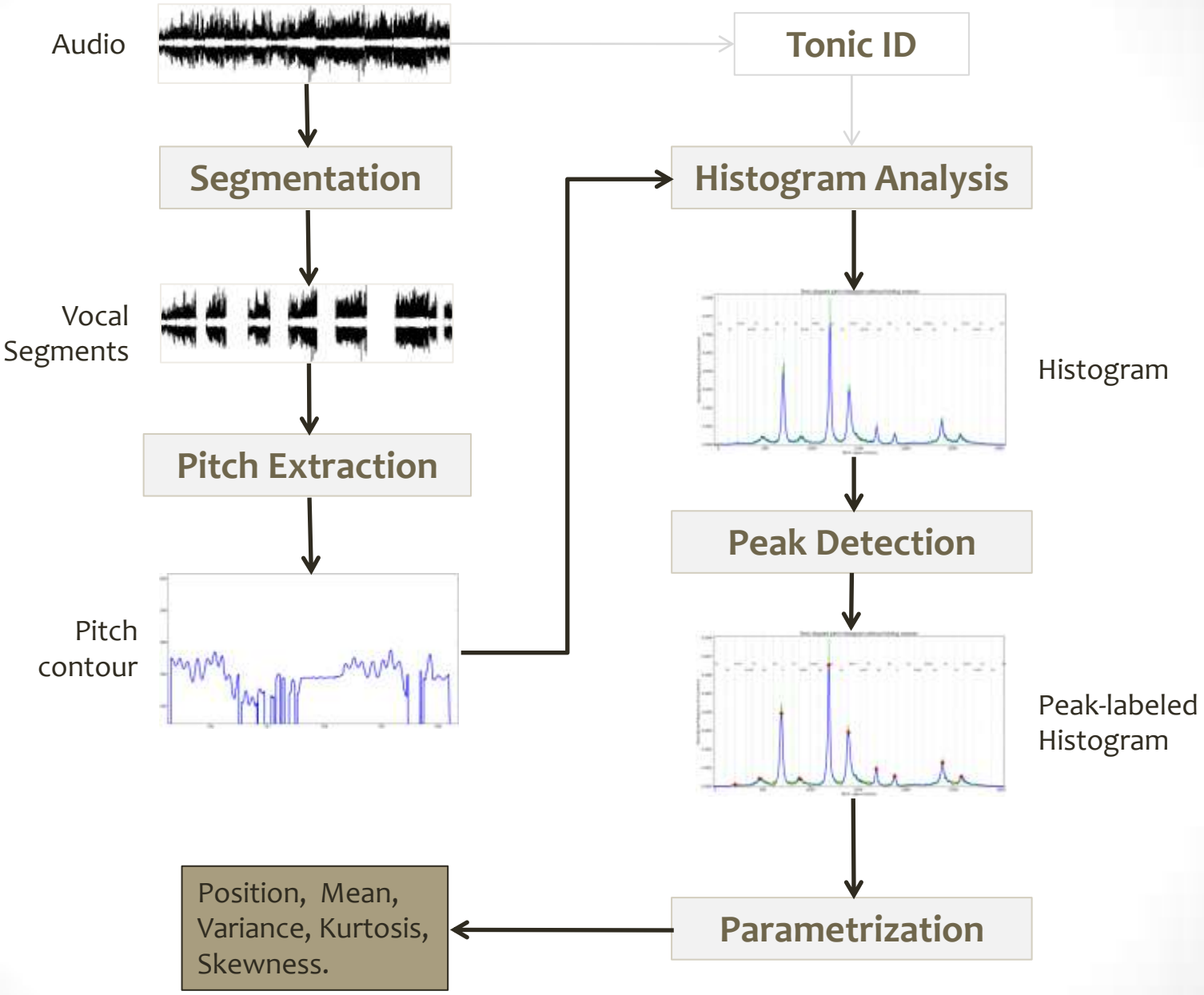
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Histogram Analysis

- … bin resolution!
- Histogram

$$H_k = \sum_{n=1}^{N} m_k$$

H_k is k^{th} bin count, N is fnumber of pitch values,
$m_k = 1$ if $c_k \leq P(n) \leq c_{k+1}$ and $m_k = 0$ otherwise. P is array of pitch values and c_k, c_{k+1} are bounds of k^{th} bin.

- Purpose of average histogram
  - Reliability of peak estimation in single histogram

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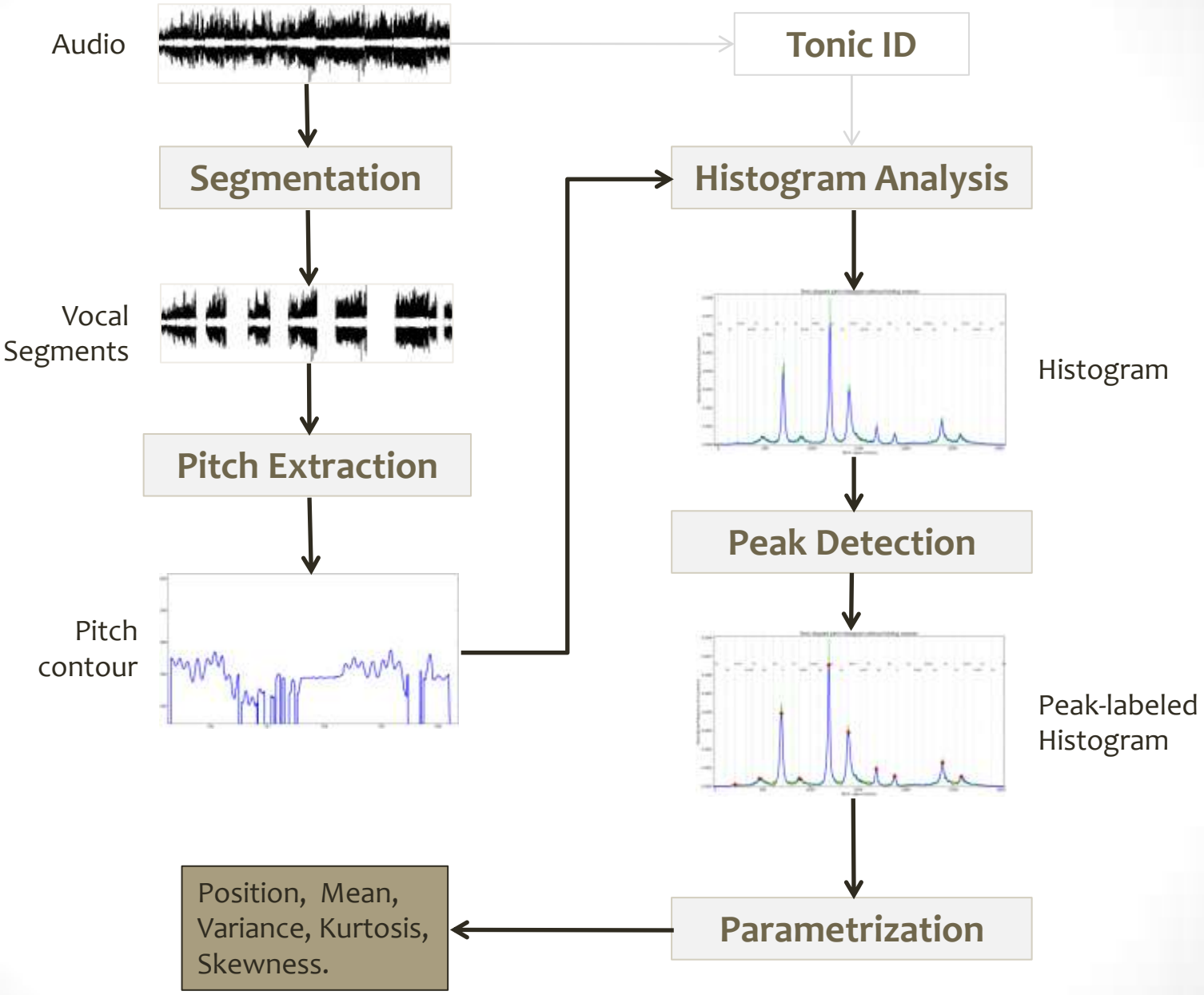
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Peak Detection

- Pitch contour smoothed using a Gaussian kernel
- D_p and L_p: Depth and look-ahead parameters
- Valleys are deeper than D_p
- Peaks are local maxima
  - Locality: L_p bins ahead.
- Average histogram
  - D_p and L_p set to higher values
- Histogram of a single recording
  - D_p and L_p set to lower values

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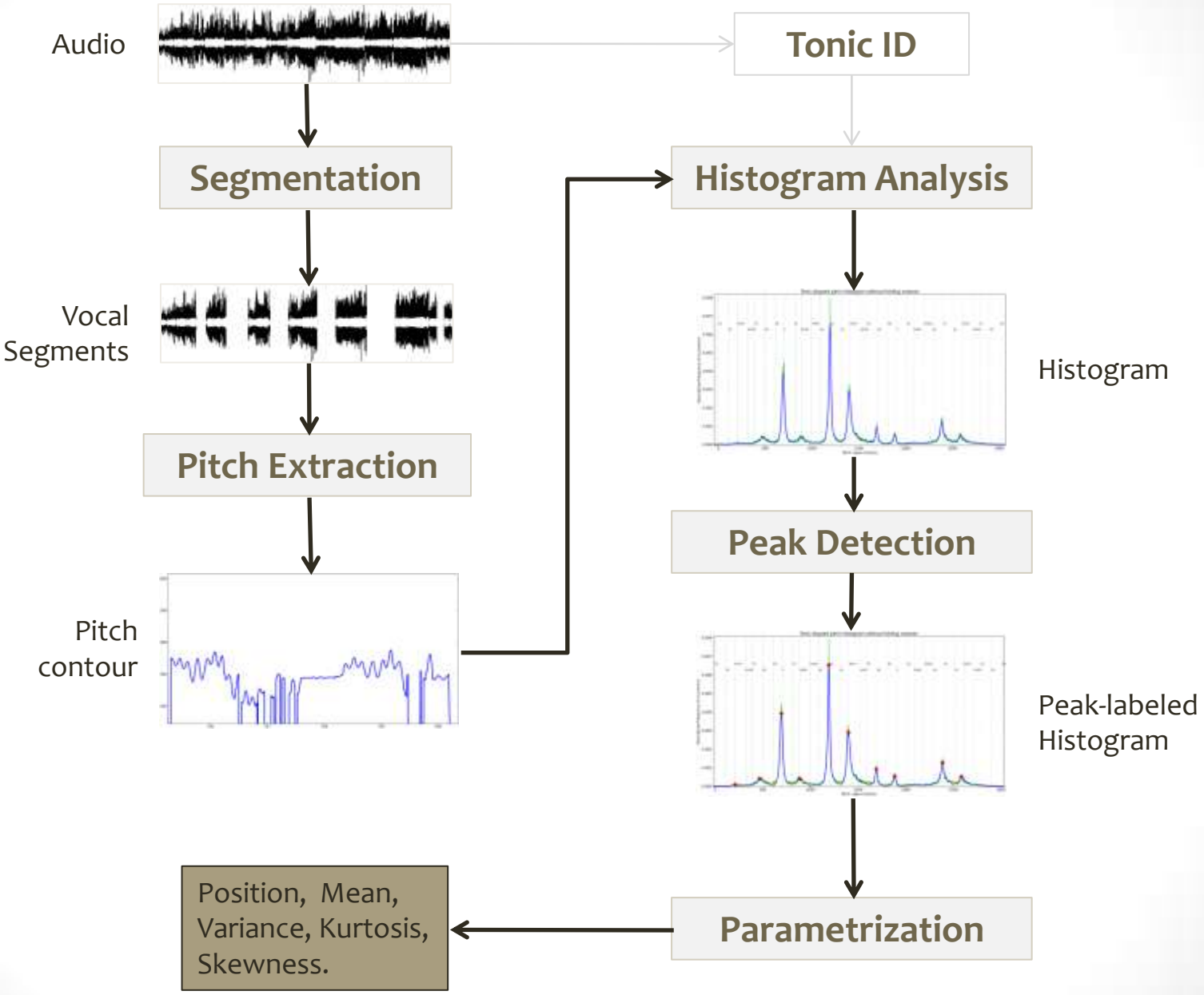
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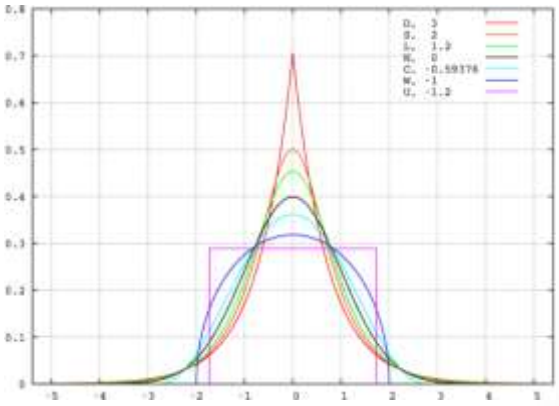
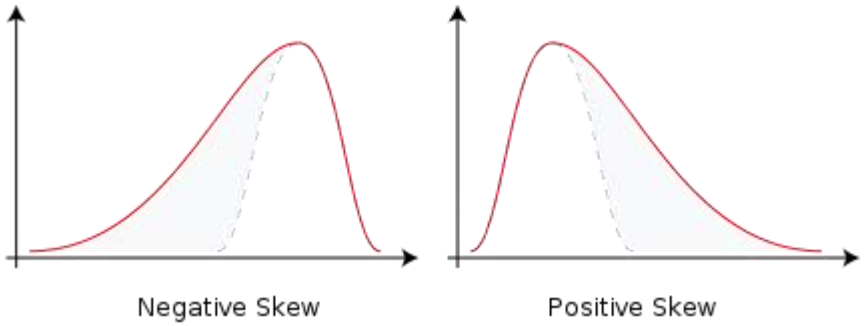
Parametrization

- Distribution bounds
- Calculate the parameters
  - Position
  - Mean
  - Variance
  - Kurtosis (Peakedness)
  - Skewness (Slantedness)





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Data

- Subset of CompMusic Carnatic dataset
  - 16 raagas, 170 recordings (at least 5 per raaga), 35 vocalists

- **Task 1:** Explorative raaga recognition task
  - 3 raagas, 42 recordings
  - 2 raagas, 26 recordings
- **Task 2:** Distinguishing allied raagas
  - 3 sets, 7 raagas, 60 recordings
- **Task 3:** Analysis of peak positions
  - *All* recordings from the subset!

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Results (1/3)

Features/Classifier	Naive Bayes	1-Nearest Neigh.	SVM	Logistic Regression	Random Forest
Mean and Height	63.43%	56.67%	61.81%	56.33%	64.62%
All parameters combined	63.76%	68.90%	65.19%	68.86%	70.71%

Table 1. Results of an exploration raaga classification test with 42 recordings in 3 raagas using different classifiers. The random baseline accuracy in this case is 28.57%.

Features/Classifier	Naive Bayes	1-Nearest Neigh.	SVM	Logistic Regression	Random Forest
Mean and Height	39.6%	39.85%	41.25%	43.65%	48.85%
All parameters combined	58.05%	67.6%	74.25%	77.45%	74.45%

Table 2. Results of an exploration raaga classification test with 26 recordings in 2 raagas using different classifiers. The random baseline accuracy is 20% in this case.

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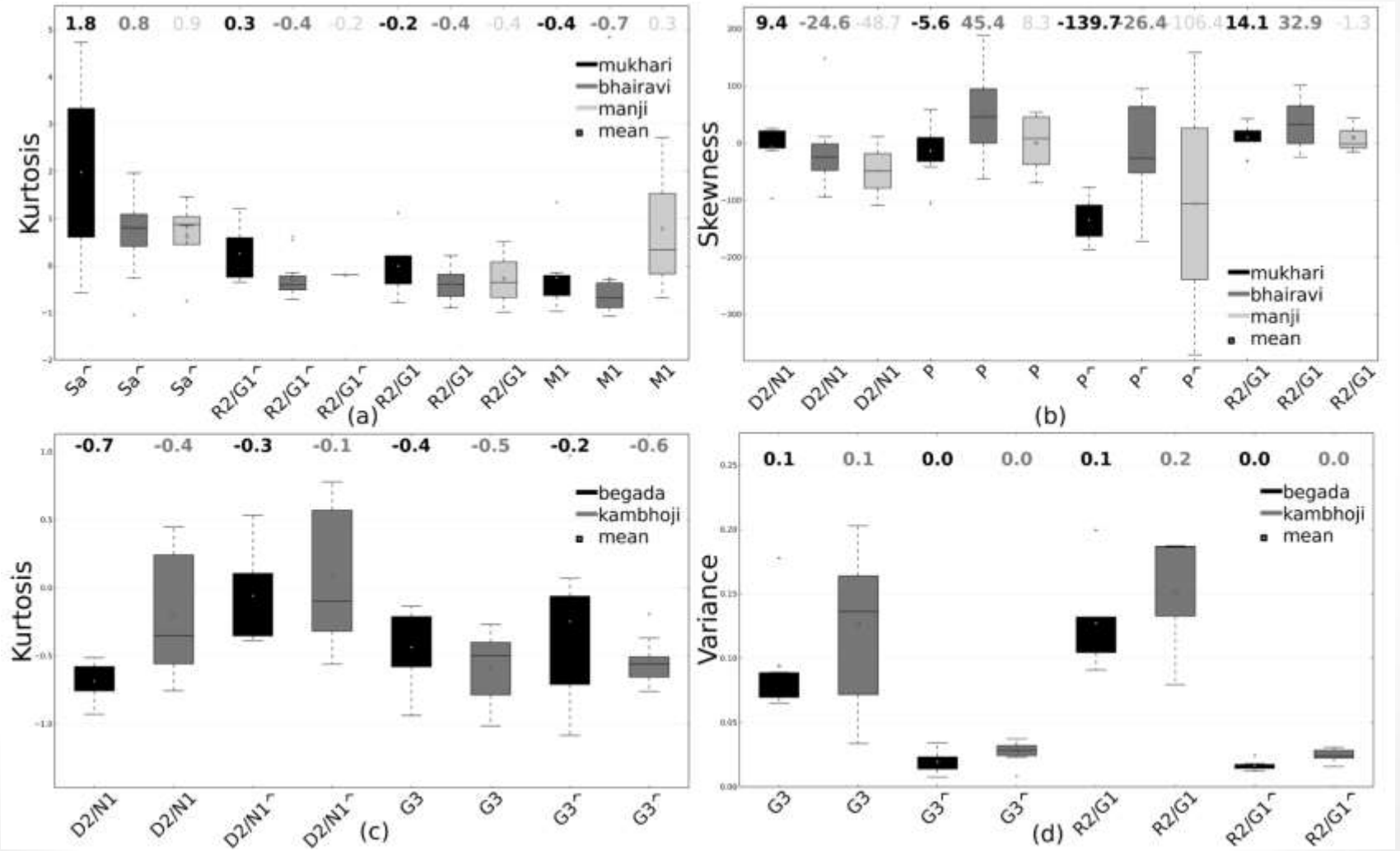
Results (2/3)



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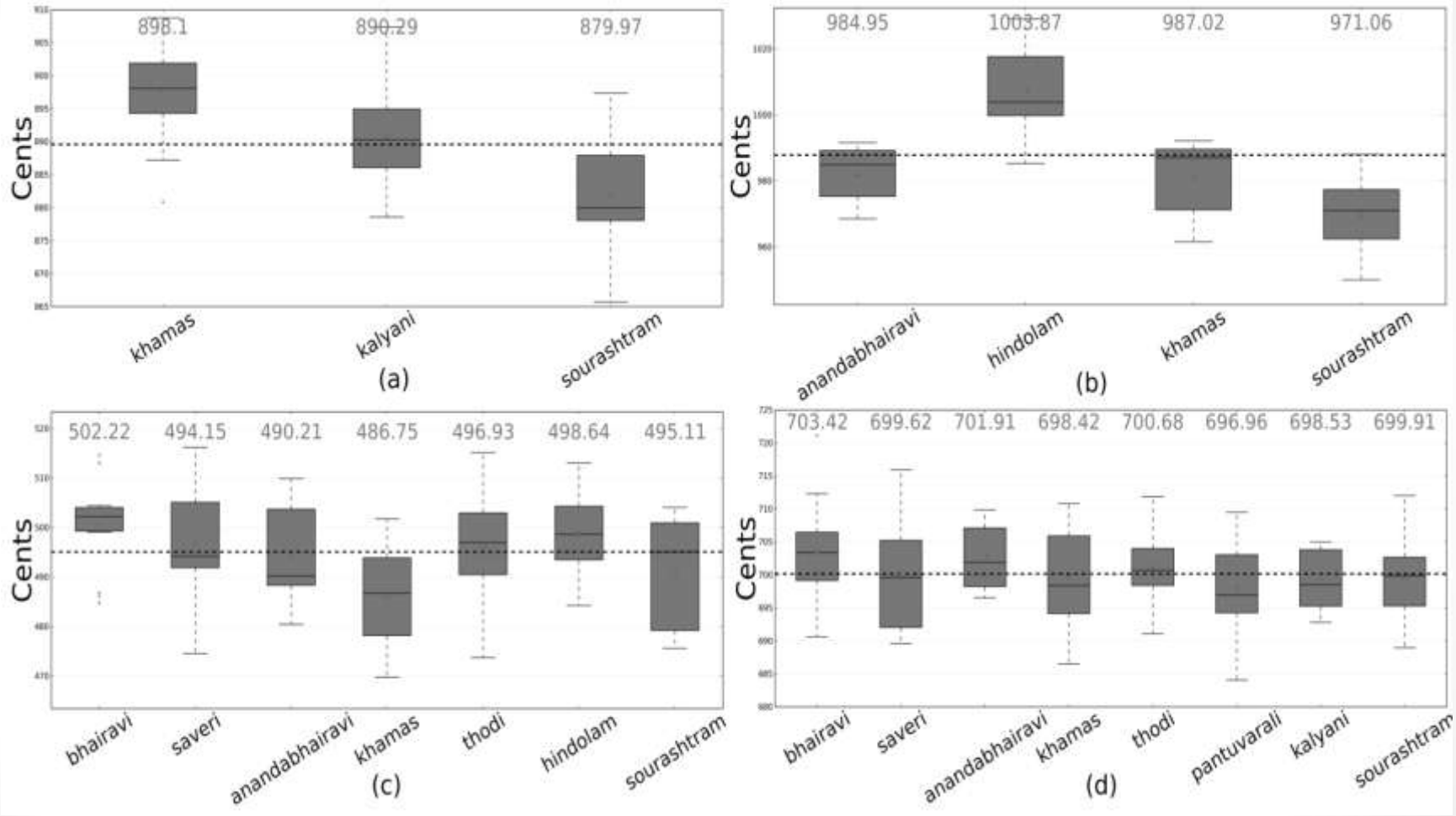
Results (3/3)



Peak positions of (a). D2, (b). N2, (c). M1 and (d). P. The dashed line shows the mean of the corresponding swara obtained from the general template.

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Back to the browser!

- As a similarity measure for raagas
  - Characteristics of common swaras
- Evolution of raagas
  - Composed sections
- As a similarity measure for artists & schools
  - Especially, the improvised sections

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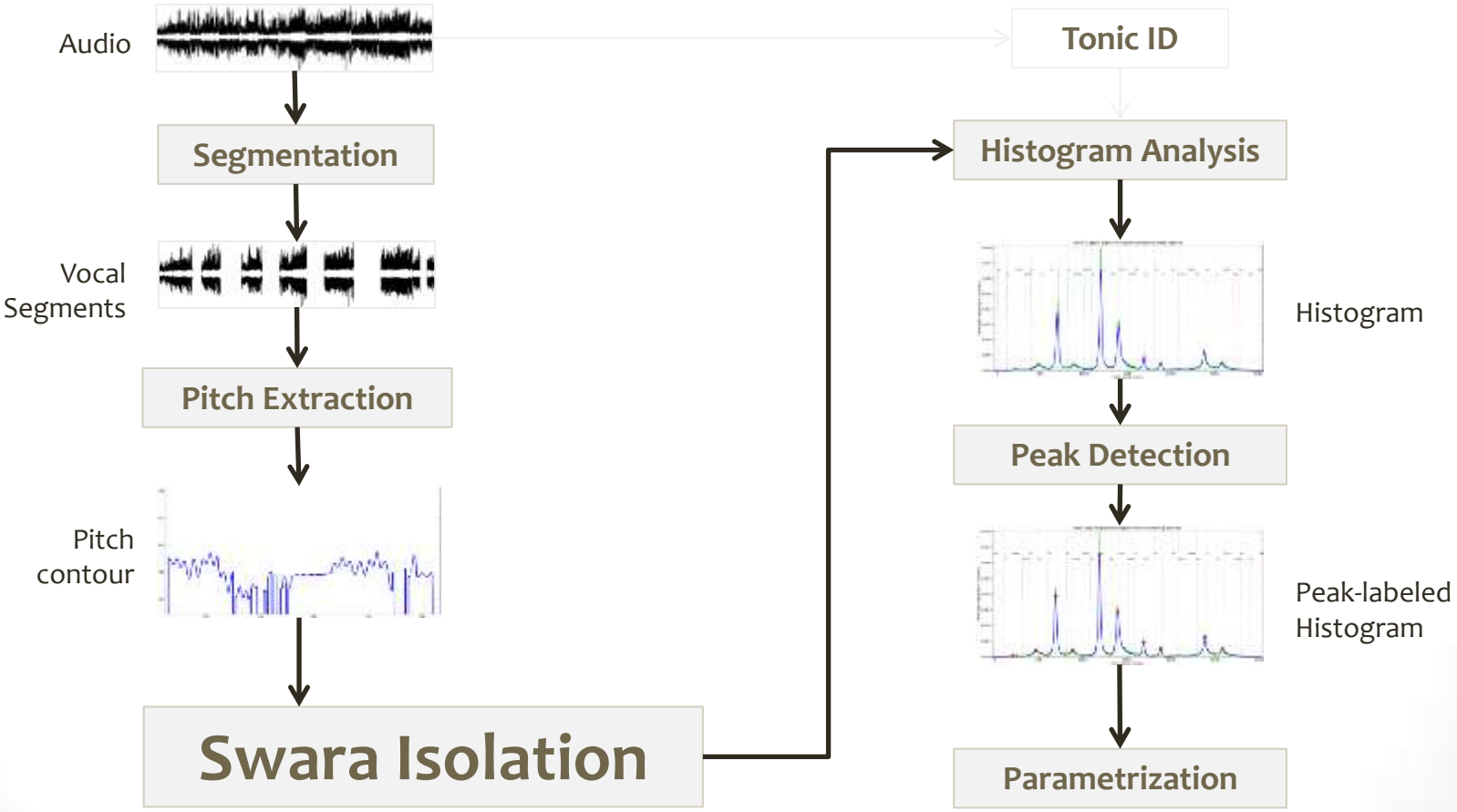
Swara Isolation [Work in progress]



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Swara Isolation [Ideas]

- Why?
  - Discard the irrelevant/non-contextual pitch values
    - How do we discriminate??
  - Much clearer distributions
- Moving window & mean frequency
- Histogram per swara
  - Multiple peaks indicating the ‘contribution’ or ‘interaction’ of other swaras

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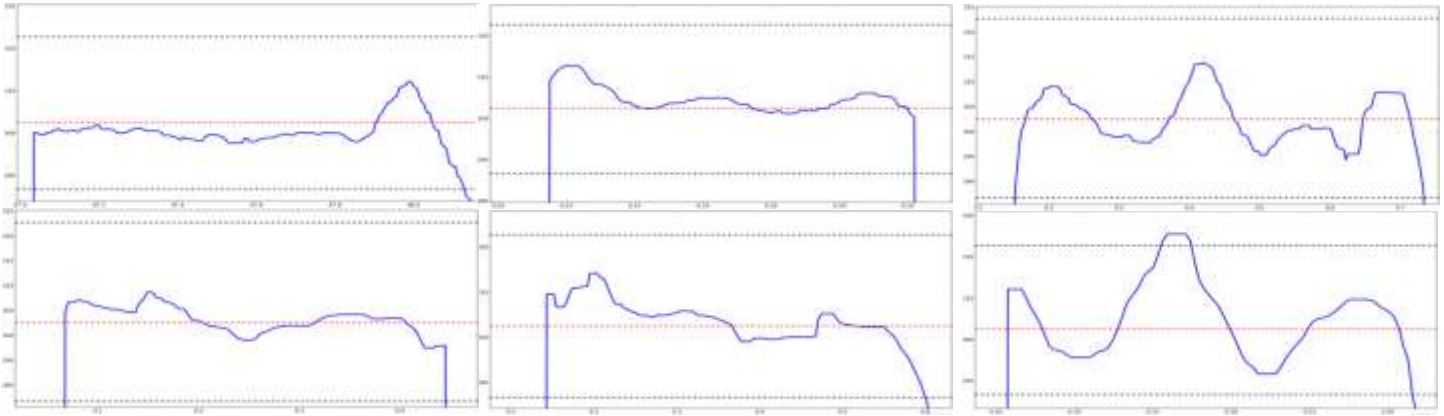
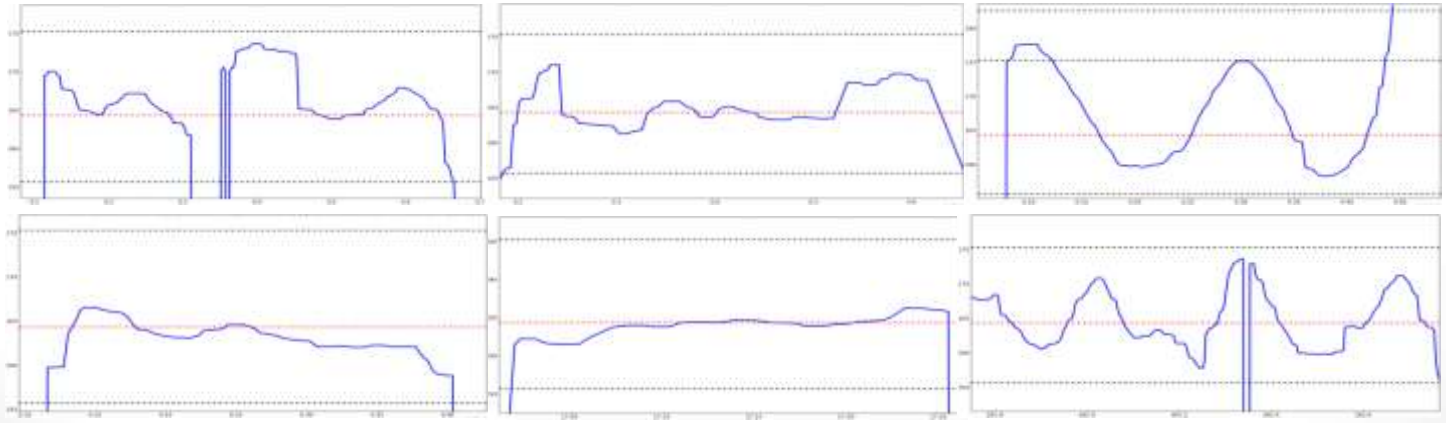
Pattern Analysis [Work in progress]

R_2 in Mukhari



R_2 in Bhairavi



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Pattern Analysis [Ideas]

- Why?
  - Patterns as atomic units of description
  - Similarity measures directly involving patterns
- Dictionary of patterns
  - All gamaka patterns on all swaras?
  - Just the characteristic gamakas?
  - Phrases instead of swaras (hierarchical)?
- Scale-invariant pattern matching techniques

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Questions & Discussion

Ideas and brain-storming during tea-session are most welcome!!

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