

# Motif Spotting in an Alapana of Carnatic Music

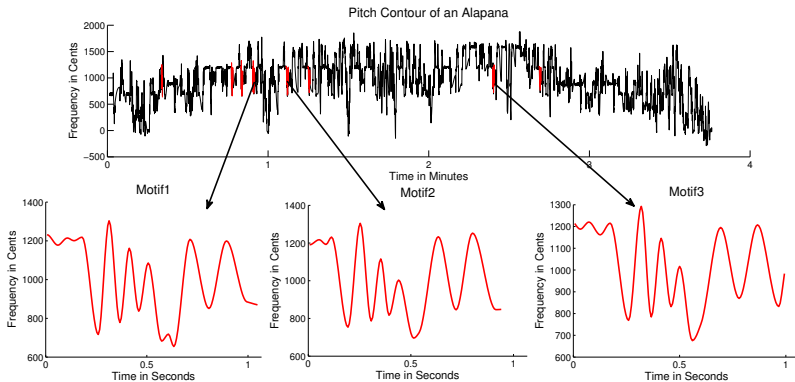
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- The Task
- Saddle Points
- Conventional Techniques
- Rough Longest Common Subsequence
- RLCS-modified
- Voiced Portions in Alapana
- Two-Pass RLCS
- Results

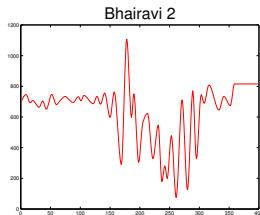
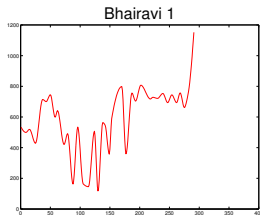
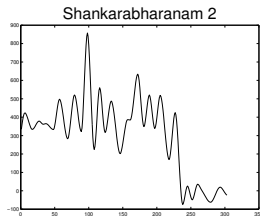
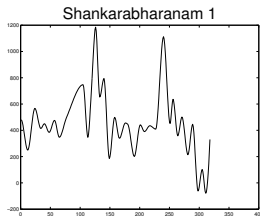
# The Task

- Spotting motifs, given by an expert, in an alapana



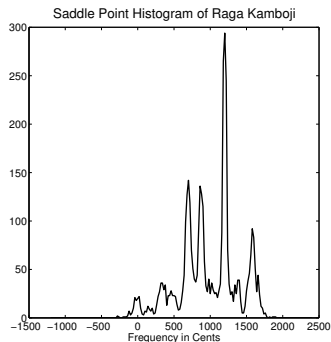
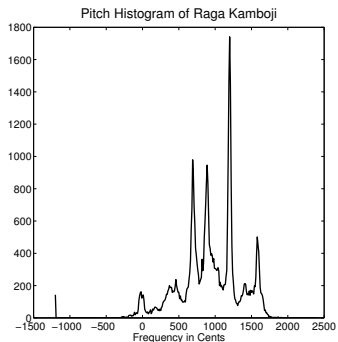
# The Task (Contd...)

- Not trivial
  - Motifs vary in terms of duration
  - Laden with gamakhas (inflected notes)





# Saddle Points

- Points in pitch contour where first derivative is zero (minima and maxima).
- Quasi-stationary points — raga information preserved.
- Reduces search space significantly.



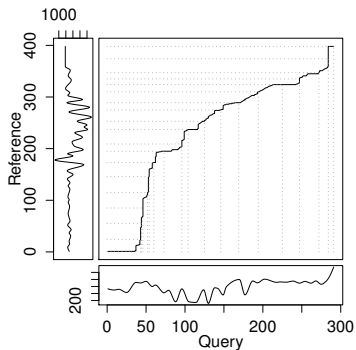
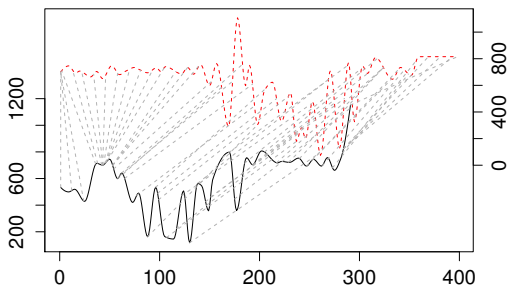
## Saddle Points (Contd...)

- Original line in Raga Thodi 
- Resynthesized line in Raga Thodi from smoothed pitch contour where saddle points are used for smoothing 

- Dynamic Time Warping
- Unconstrained Endpoint - Dynamic Time Warping
- Longest Common Subsequence

# Conventional Techniques (Contd...)

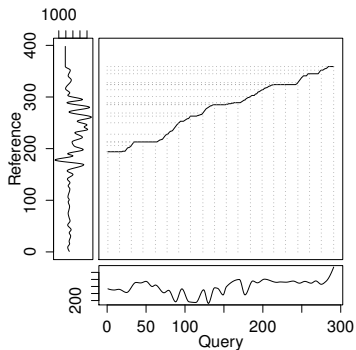
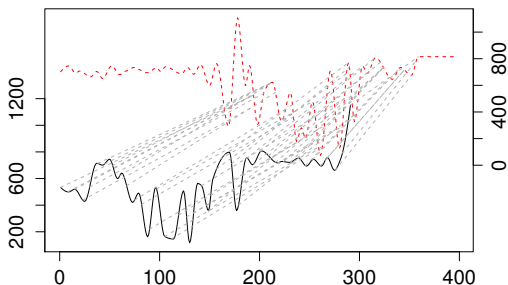
- DTW





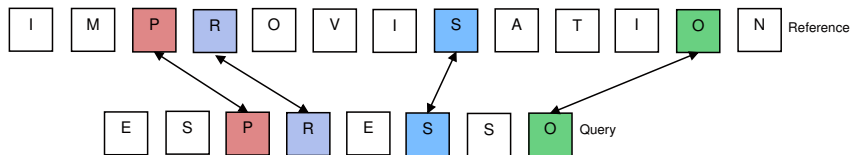
# Conventional Techniques (Contd...)

- UE-DTW

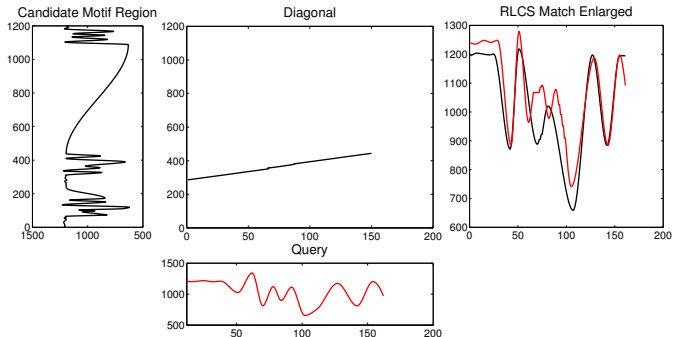


# Conventional Techniques (Contd...)

- LCS



# Rough Longest Common Subsequence



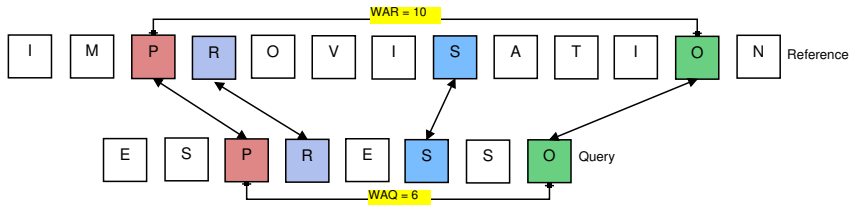
# Rough Longest Common Subsequence

- Cost computation

$$c_{i,j} = \begin{cases} 0 & ; i.j = 0 \\ c_{i-1,j-1} + \mathbf{1} & ; r_i = q_j \\ \max(c_{i-1,j}, c_{j-1,i}) & ; r_i \neq q_i \end{cases} \quad \text{LCS} \quad \left| \quad c_{i,j} = \begin{cases} 0 & ; i.j = 0 \\ c_{i-1,j-1} + \delta_{i,j} & ; r_i \approx q_j \\ \max(c_{i-1,j}, c_{j-1,i}) & ; r_i \not\approx q_i \end{cases} \quad \text{RLCS}$$

# Rough Longest Common Subsequence (Contd...)

- Width-Across-Reference (WAR) and Width-Across-Query (WAQ)
  - Smallest string containing the subsequence
  - Used for local similarity



## Rough Longest Common Subsequence (Contd...)

- Score computation

$$Score_{i,j} = \begin{cases} \left( \beta \frac{c_{i,j}}{w_{i,j}^r} + (1 - \beta) \frac{c_{i,j}}{w_{i,j}^q} \right) \cdot \frac{c_{i,j}}{n} & \text{if } c_{i,j} \geq \rho n \\ 0 & \text{otherwise} \end{cases}$$

- Using Rough-WAR and Rough-WAQ instead of WAR and WAQ

$$w_{i,j}^r = \begin{cases} 0 & ; i,j = 0 \\ w_{i-1,j-1}^r + \mathbf{1} & ; r_i \approx q_j \\ w_{i-1,j}^r + 1 & ; r_i! \approx q_i, c_{i-1,j} \geq c_{i,j-1} \\ w_{i,j-1}^r & ; r_i! \approx q_i, c_{i-1,j} < c_{i,j-1} \end{cases} \quad \text{WAR}$$

$$rw_{i,j}^r = \begin{cases} 0 & ; i,j = 0 \\ rw_{i-1,j-1}^r + \mathbf{\delta_{i,j}} & ; r_i \approx q_j \\ rw_{i-1,j}^r + 1 & ; r_i! \approx q_i, c_{i-1,j} \geq c_{i,j-1} \\ rw_{i,j-1}^r & ; r_i! \approx q_i, c_{i-1,j} < c_{i,j-1} \end{cases} \quad \text{RWAR}$$

# RLCS-Modified (Contd...)

- Change in score computation

$$\text{Score}_{i,j} = \left\{ \begin{array}{l} \text{RLCS} \\ \left( \beta \frac{c_{i,j}}{w_{i,j}^a} + (1 - \beta) \frac{c_{i,j}}{w_{i,j}^q} \right) \cdot \frac{c_{i,j}}{n} \quad \text{if } c_{i,j} \geq \rho n \\ 0 \quad \text{otherwise} \end{array} \right. \quad \left| \quad \text{Score}_{i,j} = \left\{ \begin{array}{l} \text{RLCS-modified} \\ \left( \beta \frac{c_{i,j}}{rw_{i,j}^a} + (1 - \beta) \frac{c_{i,j}}{rw_{i,j}^q} \right) \cdot \frac{c_{i,j} + c_{i,j}^a}{c_{i,j}^a + n} \quad \text{if } c_{i,j}^a \geq \rho n \\ 0 \quad \text{otherwise} \end{array} \right.$$



## Voiced Portions of Alapana

- Energy based voiced activity Detector is used to find the voiced regions
- Reduces search space.

- First Pass
  - Uses only saddle points of query and Alapana
  - Output potential motif regions
  - Fast
- Second Pass
  - Uses pitch contour smoothed using saddle points
  - Locate motifs in potential motif regions
  - Slow

# Results

- Top 3 hits in an alapana

Raga	Top 1	Top 2	Top 3
Bhairavi 	0.6824 	0.6661 	0.6614 
Shankarabharanam 	0.7950 	0.7640 	0.7482 
Varali 	0.6288 	0.6088 	0.5770 