Melodic Pattern Extraction in Large Collections of Music Recordings Using Time Series Mining Techniques

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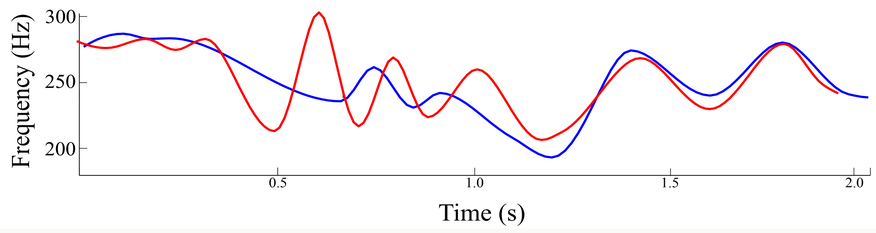
Goals

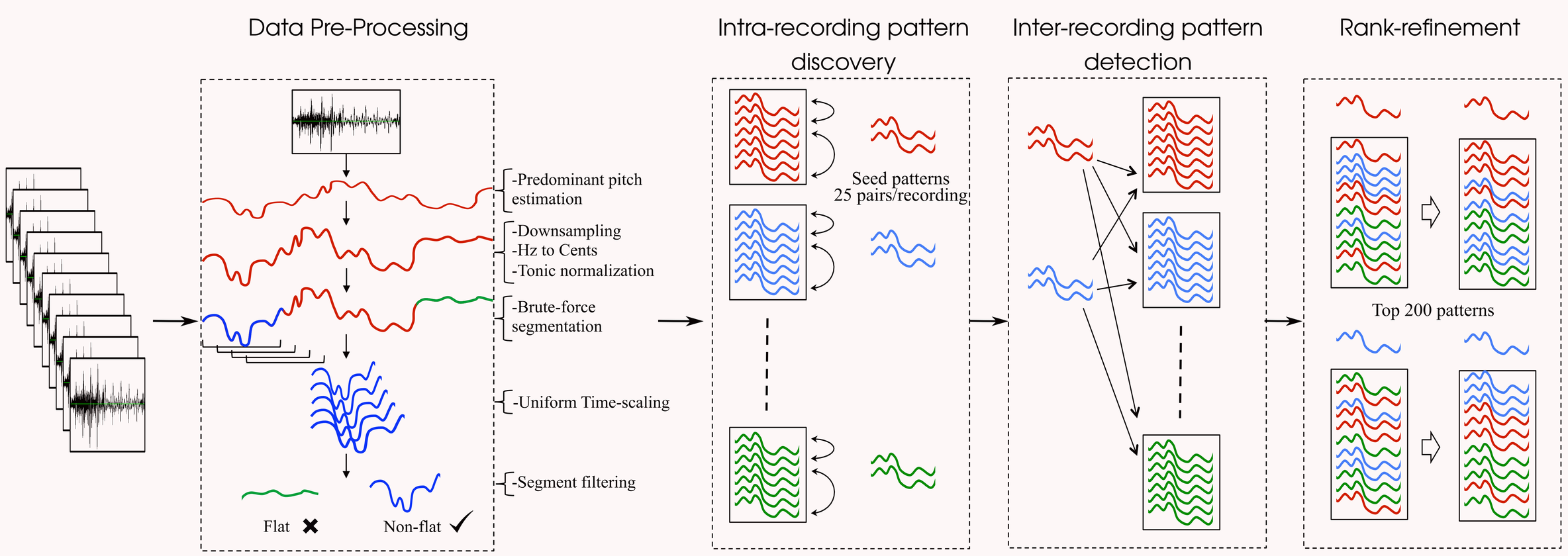
- Discover short-time melodic paterns in audio collections of Indian art music (IAM)
- Assess scalability of melodic similarity measures based on DTW
- Evaluate four variants of DTW cost function for rank refinement
- Assess the tighness of lower bounding techniques for DTW-based distance measure for the given data

Melodic Patterns in Indian Art Music

- Prominent cues for rāga identification
- Basis for melodic analysis of IAM
- Set ground for melodic improvisation
- Highly varied across repetitions



Methodology

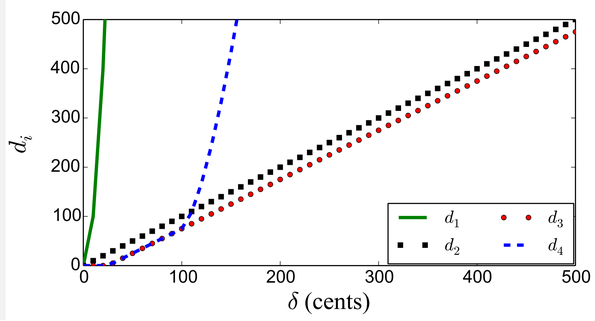


Melodic similarity

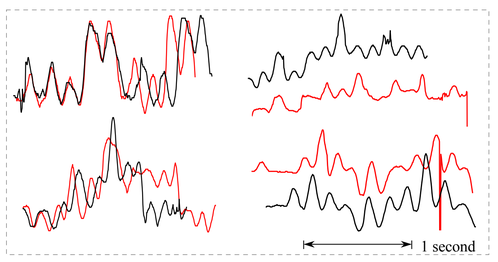
- Whole sequence matching DTW-based distance measure
- Square Euclidean distance as DTW cost function
- No local constraint and transition cost
- Step condition: {(1,0), (1,1), (0,1)}
- Sakoe-Chiba globand band constraint (10% pattern length)
- Use first-last (FL) lower bound
- Use LB_Keogh lower bound

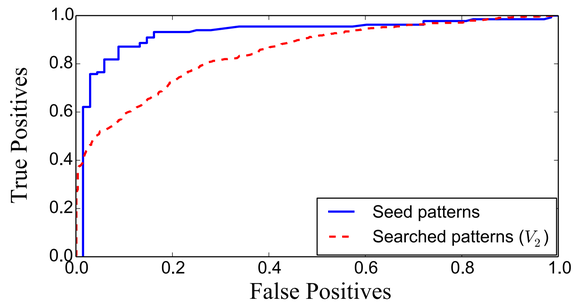
Rank-refinement

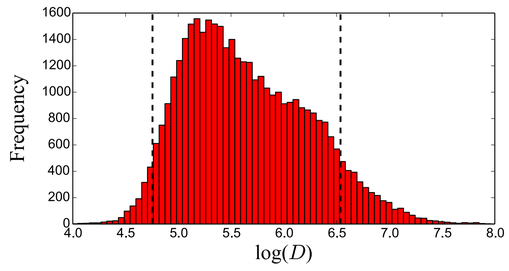
- Local constraint
- Step condition: {(2,1), (1,1), (1,2)}
- 4 different DTW cost functions
- No lower bounding used

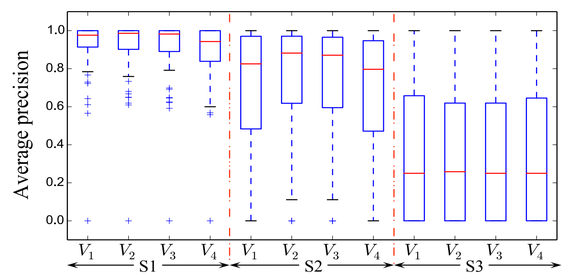


Results and Discussion









Intra-recording discovery: **1.4*10^12** DTW computations (**75%** avoided)

Inter-recording search: **12.4*10^12** DTW computations (**99%** avoided)

Evaluation

Dataset:

- CompMusic Carnatic music collection
- **1764 polyphonic audio** recordings
- **365 hours** of music material covering different forms, rāgas and artists
- Over **300 million pattern candidates**

Evaluation:

- 79,000 seed patterns & 15 million search patterns
- Randomly sample 200 seed patterns and top 10 search patterns
- Total of 8000 patterns pairs evaluated by a professional musician
- Mean averate precision (MAP) to quantify musician's assessment
- ROC curves for the anlaysis of distance distribution

Browse melodic patterns

Navigation:

- Browsing options
- Artist list
- Releases
- Recordings
- Seeds

Stop Audio

Search results using chosen seed from Nadamadi

Similarity	Seed_Id	Start(s)	End(s)	Pair_Id	Start(s)	End(s)	Musicbrainz ID (searched file)	Distance
✓	15506039	95.6	97.5	15506885	372.8	375.0	2bade8d8-1cfa-4076-9329-98f7eacc65a0	1318.68
✓	15506039	95.6	97.5	15506914	57.9	60.2	70761911-9f70-436c-97ed-d23ea74e7e0d	2416.83
✓	15506039	95.6	97.5	15506904	223.7	225.9	5c342c56-c07a-4905-89cc-bd5d1151d20a	2507.13
✓	15506039	95.6	97.5	15506891	2448.1	2450.1	1d994413-bc0a-430d-9587-419932113eaf	2554.72
✓	15506039	95.6	97.5	15506925	98.7	101.0	b6af2720-6beb-454b-ba8c-f912ea8ab27b	2573.89
✓	15506039	95.6	97.5	15506921	77.7	80.1	b6af2720-6beb-454b-ba8c-f912ea8ab27b	2615.10
✓	15506039	95.6	97.5	15506888	132.3	134.5	70761911-9f70-436c-97ed-d23ea74e7e0d	2615.37
✓	15506039	95.6	97.5	15506886	538.7	541.2	170970da-a19a-462d-8dae-4ee614f27f80	2617.46
✓	15506039	95.6	97.5	15506887	538.7	541.2	170970da-a19a-462d-8dae-4ee614f27f80	2617.46
✓	15506039	95.6	97.5	15506890	10.7	12.5	367f884a-9de9-4f45-a139-82a067c13865	2630.03
✓	15506039	95.6	97.5	15506901	69.8	72.1	bec3b237-0303-4011-9d8b-394415b0a6b2	2635.77
✓	15506039	95.6	97.5	15506900	927.7	929.9	5269b678-e274-4732-a906-ab1760ddf9c3	2658.49
✓	15506039	95.6	97.5	15506910	261.2	263.2	5c342c56-c07a-4905-89cc-bd5d1151d20a	2708.06
✓	15506039	95.6	97.5	15506899	175.1	177.1	5c342c56-c07a-4905-89cc-bd5d1151d20a	2740.02
✓	15506039	95.6	97.5	15506894	272.5	274.5	0298a06d-ff69-4d83-922d-dedbc9bfde21	2768.00
✓	15506039	95.6	97.5	15506889	663.2	665.2	829df965-78bc-4157-9346-5a3b30bf12a5	2770.42
✓	15506039	95.6	97.5	15506919	260.4	262.4	2fbb9ddc-f253-46be-a316-36f0ee111b9e	2801.36
✓	15506039	95.6	97.5	15506902	219.2	221.3	3c24d668-51e2-4ee5-a767-74f1604822eb	2827.50
✓	15506039	95.6	97.5	15506976	32.9	35.1	d7112257-77c5-4f52-a284-c73226ca4a0d	2833.71
✓	15506039	95.6	97.5	15506897	206.3	209.0	bedc82f2-d42c-4062-9fc1-832f7f1bfd62	2836.99
✓	15506039	95.6	97.5	15507021	33.0	34.9	8e310d33-0143-4357-83c8-31e8743035 5d	2852.56
✓	15506039	95.6	97.5	15506893	144.6	147.0	097411d7-b164-41b7-a604-56bdcb584886	2869.28
✓	15506039	95.6	97.5	15506913	49.8	52.0	e09a3860-8ae2-400b-8300-4d72204960b3	2878.99

- X. Serra, "Creating research corpora for the computational study of music: the case of the Compmusic project," in Proc. of the 53rd AES International Conference on Semantic Audio, London, Jan. 2014.
- J. Salamon and E. G´omez, "Melody extraction from polyphonic music signals using pitch contour characteristics," IEEE Transactions on Audio, Speech, and Language Processing, vol. 20, no. 6, pp. 1759–1770, 2012.
- D. Bogdanov, N. Wack, E. G´omez, S. Gulati, P. Herrera, O. Mayor, G. Roma, J. Salamon, J. Zapata, and X. Serra, "Essentia: an audio analysis library for music information retrieval," in Proc. of Int. Society for Music Information Retrieval Conf. (ISMIR), 2013, pp. 493–498.
- S. Gulati, A. Bellur, J. Salamon, H. Ranjani, V. Ishwar, H. A. Murthy, and X. Serra, "Automatic tonic identification in Indian art music: approaches and evaluation," Journal of New Music Research, vol. 43, no. 1, pp. 55–73, 2014.
- T. Rakthanmanon, B. Campana, A. Mueen, G.Batista, B. Westover, Q. Zhu, J. Zakaria, and E. Keogh, "Addressing big data time series: mining trillions of time series subsequences under dynamic time warping," ACM Transactions on Knowledge Discovery from Data (TKDD), vol. 7, no. 3, pp. 10:1–10:31, Sep. 2013.
- S. Gulati, J. Serrà, V. Ishwar and X. Serra, "Mining melodic patterns in large audio collections of Indian art music," in Proc. of 10h Int. Conf. on Signal Image Technology & Internt Based Systems - Multimedia Information Retrieval and Applications, 2014 [to appear]

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