Camera-Based Piano Sheet Music Identification

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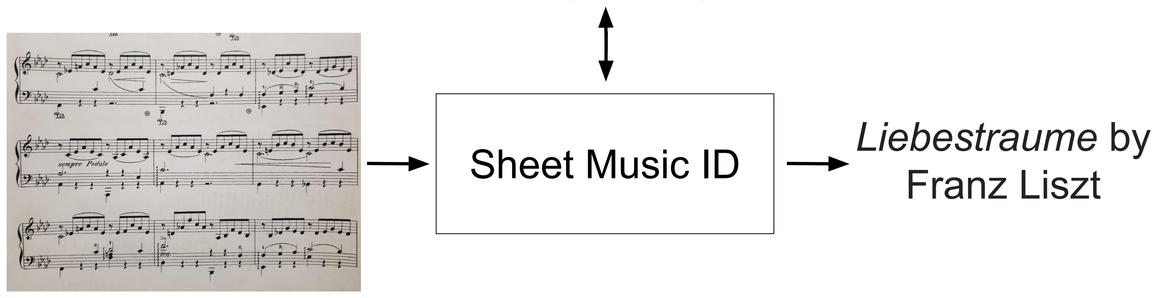
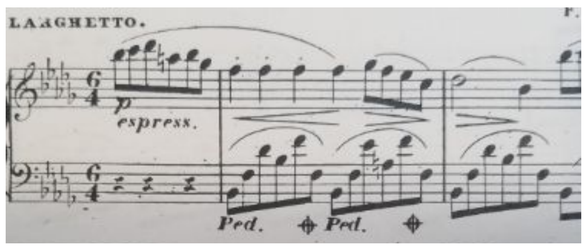
Problem Statement

Given a cell phone image of piano sheet music, identify the piece in IMSLP.

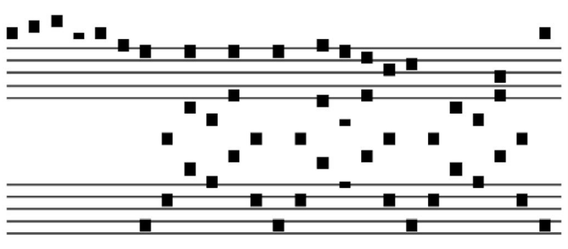


Offline Component

1 Compute Bootleg Score



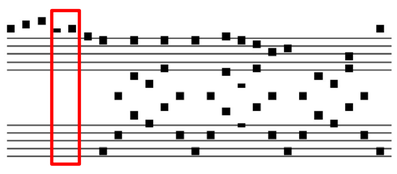
Excerpt of Sheet Music Image



Corresponding Bootleg Score

- mid-level representation that encodes position of filled noteheads [1]
- 62 x N binary matrix
- takes ~1sec/page to compute

2 Construct N-grams



$$\rightarrow x_1, x_2, x_3, \boxed{x_4, x_5}, x_6, \ldots$$

2-Gram

- Represent each bootleg score column as a 64-bit integer
- Every n consecutive integers constitutes an n-gram fingerprint

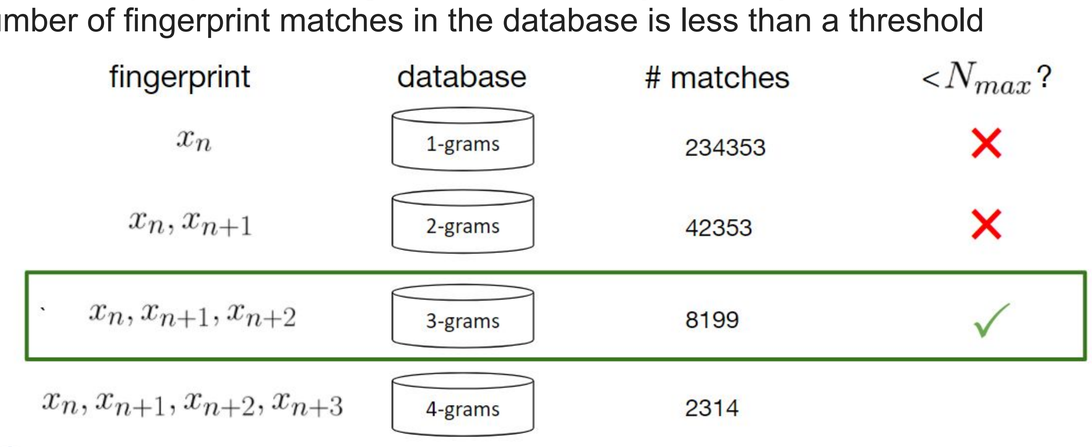
3 Construct Database

- N-gram fingerprints with N=1 to 4 compiled into reverse index
- Keys are fingerprints, values are pieces and offsets where they occur

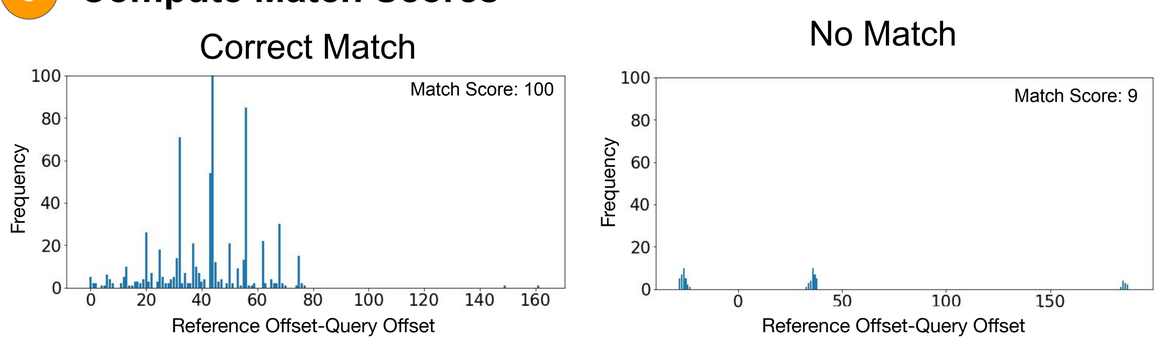
Online Component

4 Construct Dynamic N-grams

Construct a sequence of n-grams where n is dynamically chosen such that the number of fingerprint matches in the database is less than a threshold

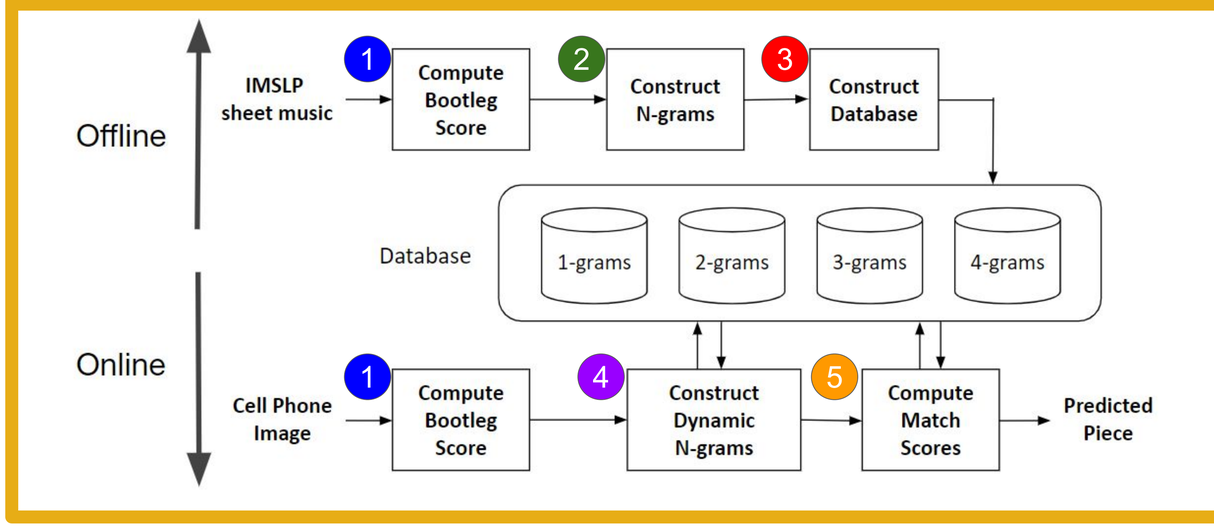


5 Compute Match Scores



Rank database items using histogram of offsets [2]

System Overview



Experimental Setup

Database

- All IMSLP solo piano sheet music
- 29,310 total pieces
- 374,758 total pages

Queries

- Taken from SMR Dataset [3]
- 2000 cell phone pictures of physical sheet music
- Images from 200 piano scores
- Each image shows 1-5 lines of music

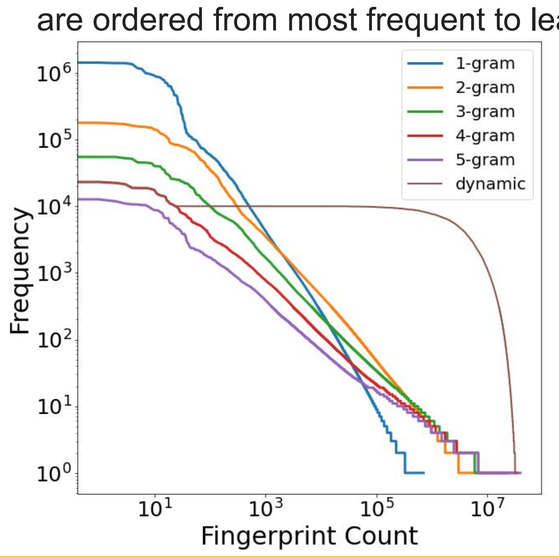
Results

System	MRR	Avg Runtime	Std Runtime
1-gram	.709	21.5s	12.5s
2-gram	.845	2.76s	.36s
3-gram	.808	1.99s	.21s
4-gram	.755	1.23s	.13s
5-gram	.688	1.07s	.08s
dynamic	.853	.98s	.12s

- Fixed n-gram has a trade off between accuracy and runtime
- Dynamic n-gram system has the highest accuracy and fastest runtime

Analysis

Plot shows frequency of each fingerprint in the database, where fingerprints are ordered from most frequent to least frequent.



- Ideal distribution for hashing is flat (uniform)
- For short n-grams, there are some fingerprints that are extremely common in the database. Leads to long runtimes.
- For long n-grams, there are a lot of fingerprints that are extremely rare (occur less than 10 times in IMSLP). Leads to worse accuracy.
- Dynamic n-gram system has a much flatter distribution than the fixed n-gram systems.

References

[1] Yang et al. “MIDI passage retrieval using cell phone pictures of sheet music” in ISMIR 2019.
[2] Wang. “An industrial strength audio search algorithm” in ISMIR 2003.
[3] Tsai et al. “Using Cell Phone Pictures of Sheet Music to Retrieve MIDI Passages” in IEEE Transactions on Multimedia 2020.

Acknowledgements

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