Taizam

Identification of music using NCD

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AUTOMATIC MUSIC IDENTIFICATION WITH NCD

Using Python and Normalized Compression Distance

Kolmogorov complexity

$$\mathrm{NID}(x,y) = \frac{\max\{K(x|y), K(y|x)\}}{\max\{K(x), K(y)\}}$$

Normalized Compression Distance (NCD)

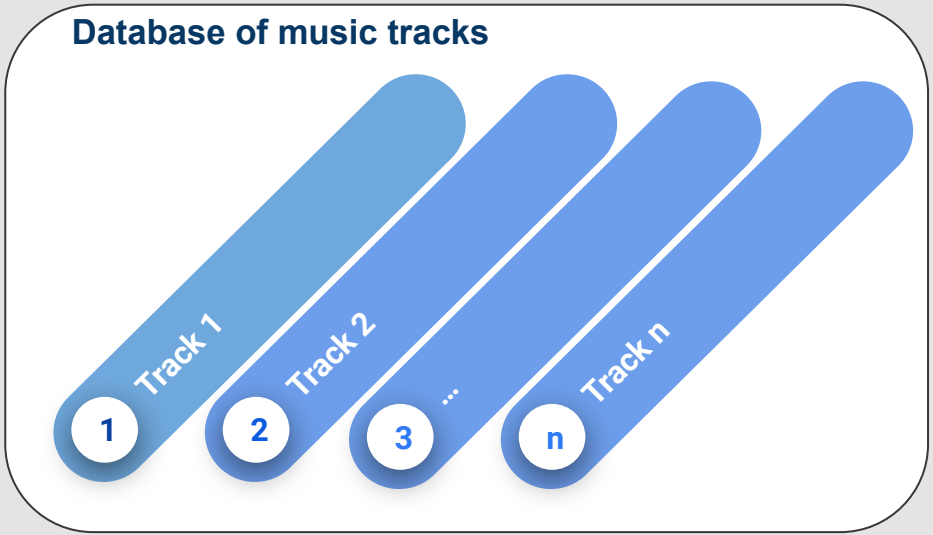
$$\mathrm{NCD}(x,y) = \frac{C(x,y) - \min\{C(x), C(y)\}}{\max\{C(x), C(y)\}}$$

NORMALIZED COMPRESSION DISTANCE (NCD)

- NCD measures similarity based on compressed data
- Powerful tool for identifying similarities in complex data (e.g. audio)
- Used to compare music segments with a database of tracks

Original track

$$\mathrm{NCD}(x,y) = \frac{C(x,y) - \min\{C(x), C(y)\}}{\max\{C(x), C(y)\}}$$



Smallest distance → Better match

INPUT PARAMETERS

- **compressor:** Choose the compressor (zlib, lzma, gzip, bz2)
- **wavFile:** Path to the WAV file to process
- **--sampleStart:** Percentage(s) of the duration of the sample (multiple values allowed)
- **--sampleDuration:** Time(s) in seconds for the sample duration (multiple values allowed)
- **--noiseLevel:** Percentage(s) of noise to add (multiple values allowed)

METHODOLOGY

1. Sample Handling
2. Generating Signatures
3. Calculating NCD
4. Check the Result

1 Sample Handling

- **Segment Files:** The selected file is segmented according to the input parameters.
- **Noise Addition:** If noise level is specified, noise is added to the segment.

2 Generating Signatures

- **Signature file:** generate original music's and sample's signature file.

3 Calculating NCD

- **Compression:** Use the compression algorithm selected in the parameters (zlib, lzma, gzip, bz2) to compress the frequency representations.
- **Compute NCD:** Use the formula to calculate de NCD

$$\mathrm{NCD}(x,y) = \frac{C(x,y) - \min\{C(x), C(y)\}}{\max\{C(x), C(y)\}}$$

4 Check the Result

- **Result:** Find the smallest distance to get the match.

RESULTS

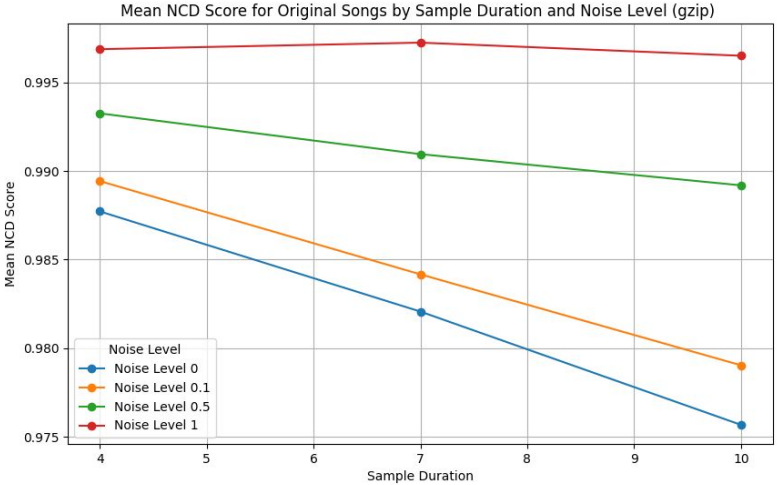
SET OF TESTS

- Set of tests using each compressor - *zlib*, *lzma*, *gzip*, *bz2* - with zero noise level (no noise added) and a duration of 10 seconds.

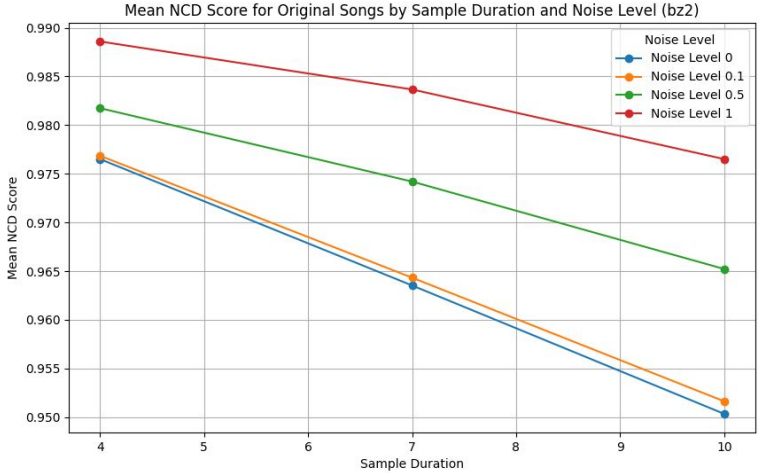
- Set of tests using the two best compression algorithms with different noise levels (0, 0.1, 0.5, 1.0) and a specific sample configuration (duration 4s, 7s, 10s).

Best NCD (samples with 10s and 0 noise)				
File	bz2	gzip	lzma	zlib
Adeste-Fideles-Shorter.wav	0.938	0.960	0.903	0.962
cozycoffeehouse.wav	0.962	0.985	--	0.986
sunlitdepths.wav	0.957	0.979	--	0.981
The_Throne_Silent_Partner.wav	0.948	0.972	--	0.974
Theme_for_Harold_var_3.wav	0.921	0.960	0.908	0.962
mean	0.945	0.971	0.905	0.973

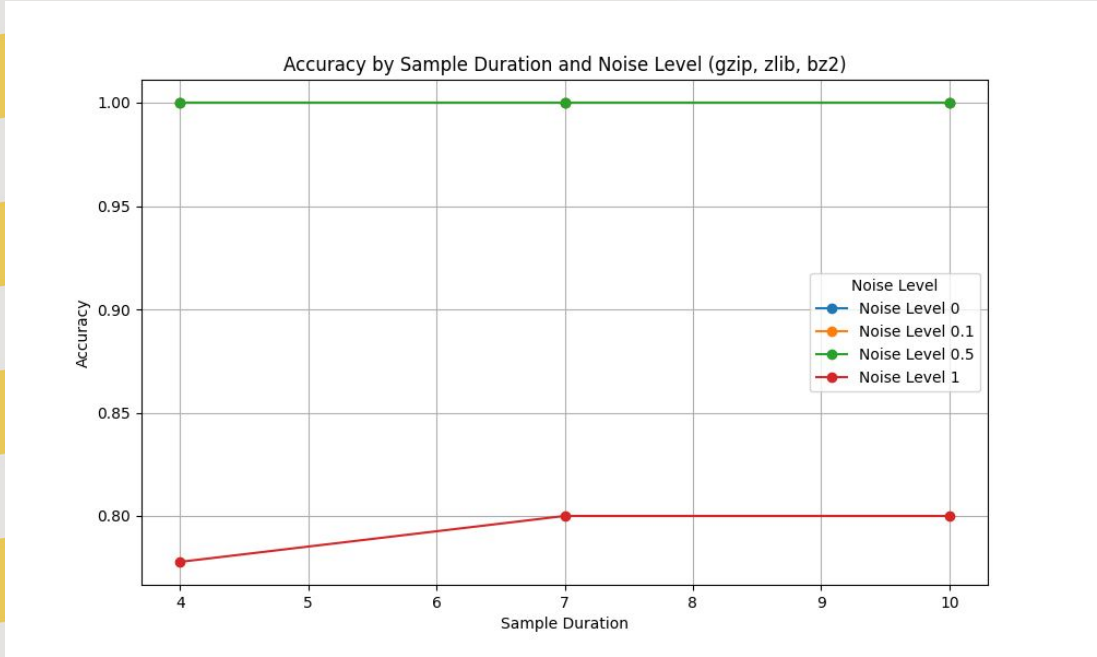
Best NCD  bz2



NCD Score vs Sample Duration vs Noise Level



Accuracy


Accuracy by Sample Duration and Noise Level (gzip, zlib, bz2)
Accuracy
1.00
0.95
0.90
0.85
0.80
4
5
6
7
8
9
10
Sample Duration
Noise Level
Noise Level 0
Noise Level 0.1
Noise Level 0.5
Noise Level 1

CONCLUSION

1. For "clear" music, NCD can almost guarantee sample identification with near 100% accuracy.
2. Compression algorithms bz2, gzip, and zlib performed well and are suitable for this use case. Unlike Lzma that showed negative results.

3. The methodology is effective for identifying music samples contaminated by noise.
4. Increasing noise levels raise the NCD but do not significantly affect identification accuracy.

5. Smaller samples increase the difficulty of the task but do not make it impossible.

6. The tested methodologies show that NCD is a viable technique for music identification within the tested parameters.

FUTURE WORK

- Tests with more compression algorithms.
- Expanding the music database
- Test robustness with musics produced with similar audio. samples as is happens nowadays.
- Test other music file formats, different from .wav.