AUTOMATIC CHORD RECOGNITION USING ESSENTIA ALGORITHMS

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1. PROBLEM DESCRIPTION

In this project, we will perform a chord detection analysis using low-level feature extraction from Essentia, Essentia's chord detection algorithms, and the Beatles studio discography dataset [1]. The results will be evaluated by comparing to the chord annotations provided on the Isophonics website, which have been tried and true by the MIR community. These annotations are provided in the following format: `start-time end-time chord-label` . This project was loosely based off of Chris Harte's doctoral dissertation [7], as the origin the reference dataset and a seminal paper on chord recognition in MIR.

2. METHODOLOGY

Once the dataset of Beatles studio albums was collected, the audio files could be processed through a set of Essentia algorithms to extract low-level features and compute pitch class profiles (HPCPs). The methodology used can be summarized in four steps:

1. Load audio in mono format
2. Slice audio into frames HPCP and peak picking
3. Apply chord-detecting algorithm (either ChordsDetection() or ChordsDetectionBeats())
4. Store results in .lab file for each track and analysis method.

2.1 Evaluation Methods

Once all tracks have been evaluated and .lab files have been created for each track, these lab files can be compared to the reference .lab files, obtained from the Isophonics website [6]. The .lab files were compared using mir-eval.chord.mirex(), where "an estimated chord is considered correct if it shares at least three pitch classes in common." [5] The scores from mir-eval consist of weighted accuracies, ranging from 0 to 1 (1 being the best score).

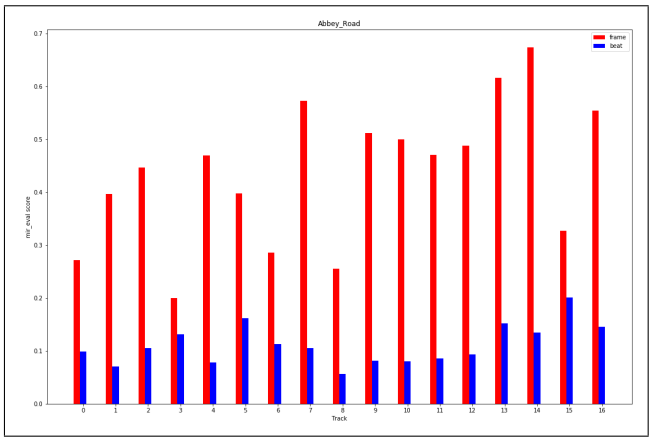

Figure 1. Scores for each track on the *Abbey Road* album compared for both Essentia algorithms. Results from ChordsDetection are shown in red, and results from ChordsDetectionBeats in blue.

3. IMPLEMENTATION

This analysis was implemented in a Jupyter Notebook [4] using Python 3. The computed chord annotations for both algorithms were computed per track and stored in individual .lab files.

4. RESULTS

The resulting scores were shown in bar graphs, where the results for both algorithms were plotted side-by-side to allow for easy comparison. Plots were created for each album in the dataset, then the average score for each album was calculated and plotted alongside all other average album scores.

Figure 1 shows the results from the analysis on the *Abbey Road* album. Figure 2 shows the results from the analysis on the *The Beatles CD2* album. Figure 3 shows the comparison the overall average score on a per-album basis.

Table 1 shows the overall average scores for all albums, for the frame-based and beat-based analyses, respectively. Both algorithms did not score that high, considering the mir-eval scores range from 0 to 1. However, the frame-based analysis obtained significantly better results overall. This was apparent across the graphs for all albums, and is summarized in these two values.

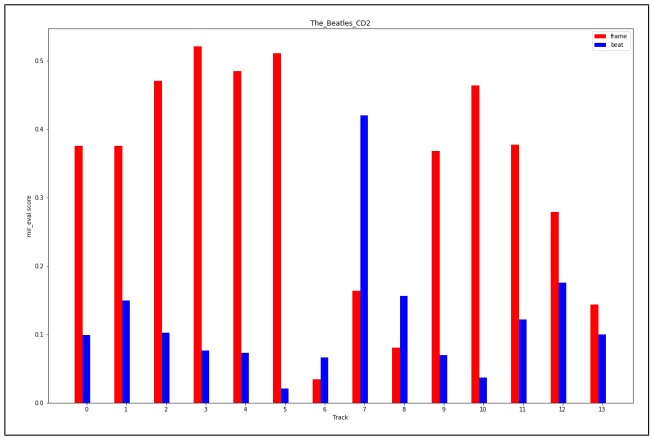

Figure 2. Scores for each track on the *The Beatles, CD2* album compared for both Essentia algorithms. Results from ChordsDetection are shown in red, and results from ChordsDetectionBeats in blue.

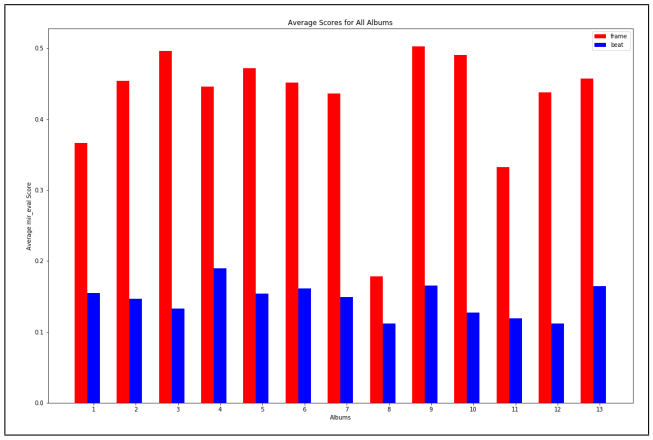

Figure 3. Average scores for each album compared for both Essentia algorithms. Results from ChordsDetection are shown in red, and results from ChordsDetectionBeats in blue.

Algorithm	Average mir-eval Score
ChordsDetection	0.42461
ChordsDetectionBeats	0.14542

Table 1. Average mir-eval score across all albums.

5. DISCUSSION

The results from the comparison bar graphs show that the ChordsDetection algorithm vastly outperforms ChordDetectionBeats on all Beatles albums.

This is almost unanimous; in fact, the only track on which ChordsDetectionBeats has a better score is Helter Skelter, off of the second disc of the White album. Figure 2 shows the bar chart obtained from *The Beatles* (The White Album), with Helter Skelter at Track 7. This is a curious result, which could be attributed to the fact that Helter Skelter is has very prominent beats, which resulted in a better segmentation coming from the beat-based analysis. The guitar on this track is heavily distorted, which may have affected the chord detection in the frame-based analysis.

The plot in Figure 3 clearly shows the ubiquity of the frame-based algorithm's lead over the beat-based algorithm. It is interesting to see that the frame-based chord detection scored exceptionally low for the Sgt. Pepper Lonely Hearts Club Band album. This album is a standout in terms of musical genre within the Beatles discography, so this out-liar could be due to a fallback in the frame-based performance for these songs. However, the songs on this album are all clearly tonal, with little distortion, so this score cannot be directly explained by a musical derivative.

It is also important to note that while the frame-based algorithm scored higher than the beat-based algorithm, its average score still did not surpass 0.5. On a scale of 0 to 1, this is not a great score. These are complex and polyphonic recordings, and by looking through a sample lab file showing the frame-based chord annotations, it shows that the algorithm changes estimated chords quite dramatically from frame to frame.

It may improve the results to single out the instrument producing the main chords, through chroma features. This would be hard to do in terms of contextualizing the results for different types of music. For instance, with The Beatles, the chords are usually played either with electric rhythm guitar or piano. The spectral/chroma parameters should be tweaked contextually for different datasets.

The two Essentia chord-detecting algorithms used for this analysis have some setbacks to note that may explain at least partway why they scored low. The algorithms are limited in the chords that they are able to detect. Both only output major and minor triads, which limits the range of chords output (i.e.: The Beatles discography often uses variations on major/minor triads).

Under the Essentia algorithm reference, both algorithms are listed as having 'experimental' quality (e.g.: prone to errors) [2] [3], so it was not expected that the mir-eval results would be high scores.

6. REFERENCES

[1] The beatles studio discography. Provided by author, not included due to copyright and distribution laws.

[2] Essentia algorithms reference: Chordsdetection(). `https://essentia.upf.edu/`

documentation/reference/streaming_ChordsDetection.html.

[3] Essentia algorithms reference: Chordsdetectionbeats(). https://essentia.upf.edu/documentation/reference/std_ChordsDetectionBeats.html.

[4] Jupyter notebook. https://github.com/lindabedrani/mirproject.

[5] mir-eval documentation. https://craffel.github.io/mir_eval/.

[6] Reference annotations: The beatles. http://www.isophonics.net/content/reference-annotations-beatles.

[7] Christopher Harte. *Towards automatic extraction of harmony information from music signals*. PhD thesis, 2010.